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"FRIENDSHIP'S OFFERING."—By C Reichert

[From the Illustrated London News.]

RAPID TRANSIT IN NEW YORK.

UNDER date of October 1, Mr. William Barclay Parsons, chief engineer of the New York Rapid Transit Commissioners, submits a preliminary report of his observations in England and Paris, made during his very short visit there last summer. The report is intended merely to give, for the information of the commissioners, the leading constructive features of several railroads, chiefly underground, which he saw on that visit.

He describes first the Metropolitan, Metropolitan District and the City South London, and gives drawings of characteristic cross sections of these constructions. The construction of both the Metropolitan lines was by the cut and cover method, even along the best streets, except where great depth necessitated tunneling. No attempt was made to give the stations a pleasing appearance, and "in fact, any such attempt would have been rendered ineffective by the engine smoke and the hideous advertising signs with which the station walls in England are covered." The platforms and stairways, however, have generous proportions. The minimum platform length is 300 feet, and width about 16 feet, and the stairways are generally 8 feet wide, with an easy slope.

No attempt is made to get at a close estimate of the cost of construction, but it may be stated approximately that the ordinary two track tunnel or covered way cost for construction alone, exclusive of land, land damages, equipment and legal or other expenses, from £200,000 to £250,000 per mile; while expensive portions, as, for instance, the Cannon Street line, cost for construction alone £400,000, and it is probable that, adding other items, that mile cost not far from £1,000,000.

Mr. Parsons gives sketches and a short description of the method of constructing this part of the line. The street is but 49 feet from house to house, with a 30-foot roadway. A timber platform was laid across the street to carry the very heavy traffic. The rail level is considerably below the foundations, and the front walls of the houses were underpinned. Trenches were then sunk along the curb line, and enough earth removed from the center of the street beneath the platform to permit the roof arch to be turned, and then the remaining earth was removed and an invert laid, and finally the street surface was restored.

The City South London Railway we do not need to describe, that being doubtless well known to our readers. In the year ending June 30, 1894, this enterprise carried 6,476,505 passengers, the uniform fare being two pence. The cost of the road averaged £267,000 per mile. Mr. Parsons found the temperature here from 67 to 68 degrees when it was 69 at the surface, showing that the air was changed often enough to prevent any great loss of heat. The electrical equipment of the road is briefly described.

The Blackwall Tunnel, now building under the Thames, just east of Greenwich, is next described. This we have described shortly in the Railroad Gazette, p. 664, September 28. It is a circular tube, 24 feet 3 inches in diameter in the clear, and is intended for vehicle traffic and foot passengers. It is 6,200 feet long, 1,735 feet being open cut and 1,382 cut and cover. The rest is a tube, constructed with a shield. The contract price for the whole work is £870,000, but it will probably cost a million sterling. The Waterloo & City Railway, which we have recently described, with illustrations, is also described by Mr. Parsons.

He visited Glasgow and saw there the Glasgow City & District Railway, 2·4 miles long. Of this, one mile was built by tunneling, some of it at a depth of 100 feet. The rest was built by cut and cover and in open cut. This line was opened in 1886. It is double track, the general construction being a brick arch, with a clear span of 26 feet in rock and 27 feet where side walls are used. The cut and cover portion of the work was the most interesting, the ground being wet sand and mud. Two rows of 6-inch sheet piles were driven to clear the external lines of the tunnel when built. The surface of the street was then raised and a safety arch of concrete was turned, the ends of which rested on the piling. The water could not be pumped without drawing sand, and a drain was constructed immediately above the rock, which gradually drained the sand, permitting the tunnel to be built beneath the arch and between the piles. A typical section of this tunnel is shown in the report. Where there was no rock for the bottom, a concrete invert was turned. Omitting the open cut portion, the 1¾ miles of heavy, city, underground work cost, without equipment, £334,000 a mile, two-fifths of which represents land, right of way, and general expenses.

Later the Caledonian Railway built the Glasgow Central Railway, 6·4 miles long, double track, all in cut and cover, except some tunnels at the west end. Here some important work was done, especially under the busiest thoroughfare of the city. The ground being bad, it was decided to keep the railroad close to the surface, the top of the roof of the tunnel coming in places to within 12 inches of the street grade. This arrangement interfered with all the sewers crossing the street, and the sewer system was constructed before building the railroad. Intercepting sewers were placed in adjacent streets, substantially parallel to the railroad, and then these sewers were passed beneath the railroad at convenient points. Sewers draining the houses were rebuilt in duplicate, one on each side of the street, connecting with the nearest cross sewers. The water and gas pipes were removed to either side of the street. Two types of cross section were employed where the cut and cover method was followed, one a brick arch and the other a flat roof with plate girders and jack arches. Excavation for the side walls was first made along the curb lines. Sheet piles were driven at first, but as the driving jarred the houses, sheathing only was used afterward. When the walls had been built for some distance a section of the roof would be laid between midnight Saturday and 5 o'clock Monday morning, in which time the contractors would tear up the roadway, lay the cross girders and jack arches, and restore the pavement. The greatest number of girders thus placed in one Sunday was thirteen, corresponding to a distance of 34 feet. Then the material was removed from beneath, being lifted by a steam crane and dumped into carts. Some of the ground was so wet that it had to be drained in advance by a circular, iron lined drain, 4 feet 6 inches in diameter, driven beneath the tunnel level. This lowered the level of the ground water from 12 feet below street grade to 18 or 19 feet. On this line there are twelve stations, three of them being completely covered and six partly covered. The covered stations have either iron roofs or brick arch roofs, and are generally 600 feet long, with two platforms, each 13 feet wide. The road will be operated by steam locomotives, it connecting directly with the surface lines. Openings above will be relied upon for ventilation, except where for a distance of 3,000 feet no opening can be had, and here a 20-foot ventilating fan will be erected. This work will cost about £300,000 per mile, without equipment.

The Glasgow District Subway is built for local traffic, is circular, 6½ miles long, with two tracks, and generally is at a considerable depth below the surface. Each track is in a separate tunnel. In soft ground the tunneling is done by a shield and lined with a cast iron tube. In other places the cut and cover method was employed. The surface of the street was removed sufficiently to permit a concrete arch to be laid, supported at the end by 4-inch sheet piles, the sewer being rebuilt above. Then the ground was removed from under the arch, and the ground being wet, compressed air was used. A concrete invert was laid, then the walls and the center pier underpinning the roof between the two tunnels were built. There are 15 stations, and the platforms are from 18 to 32 feet below the level of the street and without elevators. This road will be worked by cable running at 15 miles an hour. There will be no sidings, but where the rail level is at the least depth there will be an elevator for lifting the cars to the surface. When trains stop at night they will be left at various stations where they can be inspected, cleaned and repaired. In the case of a breakdown, the following train will push the disabled one to the elevator. The construction of this was begun in 1891, and it will be finished during the coming year at a cost of about £115,000 per mile for the construction.

The Glasgow Harbor Tunnel is a large three-tube tunnel for vehicles and pedestrians. Access to the tubes at either end will be had by elevators, which are now being put in by the American Elevator Company, the steel framework for them having been supplied by the Passaic Rolling Mill Company, of Paterson. This work is now nearly completed. Compressed air was used at 28 pounds, the men working four-hour shifts. The contract price per lineal yard for each tunnel was £80, including the iron.

The Liverpool Overhead Railway is described, but our readers are so familiar with this that we may omit any note of it, as well as of the Mersey Tunnel. It may be well enough, however, to state that this is the only tunnel or underground railroad where there is a complete system of mechanical ventilation. At the two stations, 1·2 miles apart, are ventilating fans, and there is a circular ventilating tunnel 7 feet in diameter, connected at intervals with the railroad tunnel. The fans draw the air from the tunnel and fresh air passes down through the two stations. Fresh air is thus introduced where it is most needed. Access to these stations is had by elevators, of which there are three, each holding 100 people. There are also stairways and a subway which reaches to the surface on an incline of 1 in 9. To keep the tunnel dry requires pumps capable of handling about 10,000 gallons a minute, and the working of the elevators, pumps and ventilating plant is about 20 per cent. of the whole working expenses; which Mr. Parsons points out as a matter to keep in mind in considering deep tunnels. This tunnel, including land and equipment, cost about £500,000 a mile.

In Paris Mr. Parsons found a little railroad being built by the Orleans Railroad Company. It is an extension of the Chemin de Fer de Sceaux. This extension is from the Place Denfort to the Gardens of the Luxemburg, and will be in operation probably by next January. This extension, which is double track, and is 6,240 feet long, is, Mr. Parsons thinks, the most important piece of underground construction in Europe, regarded as a model for that kind of work, and is the only case where an attempt has been made to make a really handsome structure. Here the gas and water mains and sewers were rebuilt, being placed in duplicate on each side of the street, with cross connections at convenient places above or below the tunnel. The tunnel in general has stone walls and a stone arch. In a few places where head room was very limited, iron cross girders and brick arches are used. Steam locomotives will be used and mechanical ventilation has been introduced. Just outside the haunch of the main arch a small conduit has been built connecting with a fan at a station, and connecting at intervals with the tunnel, and through this the foul air will be drawn out. Fresh air will be admitted at various points along the line, openings being made in the side walls and covered with small kiosks. The road has three stations, the two termini and one intermediate station. The Luxemburg station is wholly underground, the rail level being down about 34 feet. The others are partly open. Photographs accompanying the report give some notion of the care which has been taken to get good design in general and in detail for these stations. The engineers have been successful in giving them an attractive appearance, and they even went so far as to have the lining bricks made entirely of porcelain, at a cost of about $120 per thousand at the works. They were not satisfied that enameled bricks would be sufficiently durable for the walls and roofs of the stations. The approaches have been carefully designed for the convenience of the passengers. Two stairways are used, the one for exit being somewhat larger than the one for entrance. At the Place Denfert station, which is one of the termini, there will be elevators for baggage, and at the Luxemburg station elevators for both passengers and baggage. The lighting, the operation of the ventilating fan, and of the turntable at one terminus will all be by electric power. This work will cost, including the rebuilding of the sewers, about $1,500,000 a mile.

The French engineers stated as the result of their experience that it was advisable to keep the work as close to the surface as possible. Their difficulties and the expense increased in proportion to the depth. This point was also strongly brought out by the engineers in charge of the construction of the Blackwall Tunnel. At one place there, although the plans called for tunneling, the contractors preferred to take a less price and dig from the surface, even where the depth to be reached was 65 feet, and where the soil which had been removed had to be replaced.

Mr. Parsons arrives at a number of conclusions, in most of which most engineers will agree with him. First, an underground railroad operated by steam, even with the best mechanical ventilation, would be intolerable in New York. Second, a railroad with a steady, frequent service can be worked successfully and economically by electricity. Third, an underground railroad worked by electricity has a comfortable atmosphere, and in it great changes in temperature can be avoided. Fourth, the rail level should be kept close to the surface, as excavation from the surface is cheaper and safer than tunneling. Fifth, if, however, conditions demand, a deep tunnel can be constructed, in which the circular form is best. Sixth, an underground road can be so designed as to be attractive in appearance. Seventh, the work can be carried on through a busy street without endangering the houses, and without seriously impeding travel.—Railroad Gazette.

THE MECHANIC ARTS AND MODERN EDUCATIONS.*

By R. H. THURSTON, LL.D., Director of Sibley College, Cornell University, Ithaca, N. Y.

THE relation which ought to be sustained between the existing system of mechanic arts in our country and the various educations which are taking form in these later years is a subject in which all are vitally interested; and this is especially the case in those of our States in which these arts have hitherto been undeveloped, although nature has placed at the very doors of their people every essential element of success in the production of wealth through the exercise of those arts.

Agriculture and the mechanic arts, hand in hand, produce all wealth, sustain and promote all improvements and advances in modern life, are the basis of the whole system of modern civilization. In fact, agriculture has come to be one of the mechanic arts, doing its work with tools and machinery, and prospering in proportion to the fruitfulness of invention. We may therefore assert that upon the promotion and perfection of the mechanic arts depends the future welfare of every nation.

Among all the various educations which are practiced or proposed none is so essential, so promising of advantage to the people and to the nation, as is the education of the student and practitioner in the mechanic arts.

We may make classic scholars; we may fill our pulpits, crowd the bar, overcrowd the profession of medicine; none of these, not all of these together, can do for the people an insignificant fraction of the good which may be accomplished by the suitable and effective education of the sons of mechanics who propose entering the paths pursued by their fathers.

The fact is patent and the remark almost trite; but it is well for us to observe that the nineteenth century is the beginning of an era of prime importance to humanity, and an era promising to become historically more notable than any which has preceded since creation. It is the era of science applied in the arts.

SCIENCE AND THE ARTS.

The abstract branches of learning date back to the times of the ancients; the arts date back to Tubal Cain; but the union of science and art became possible only after the physical sciences were placed upon a firm foundation by the introduction of the experimental method of the great masters in the times of Gilbert, Lavoisier and Faraday, when applied science became the basis of all the arts. Two thousand years of thought and speculation had less influence upon the material welfare of the race than have now two centuries of right methods of work in science; far less than a single century of application of the physical sciences to the promotion of the useful arts. Our whole contemporary system of industries has grown since the days of Watt, out of the development of scientific methods in invention, construction and production.

The world has been thus advanced further in a single century than in all the preceding ages. The "science of science-advancement" has been perfected, and the results have been seen in every field of human activity. Watt adopted the scientific method of investigation, and converted the wasteful, imperfect, limited use of the old Savery and Newcomen engines of his time into the wonderful machine which has since taken upon itself the whole load of productive labor of the world.

The colleges and the schools have been given of late little credit for the progress which has been made during the century in the industries and the arts; but it should be always remembered that it is to the Senate of the University of Glasgow that we owe the discovery of James Watt, and, through that discovery, all that wonderful expansion of every art which followed the introduction of the modern steam engine, without which even modern science would have had but a stunted growth, and the arts a still more limited development.

Applied science, in the hands of Watt, proved the mainspring of all subsequent growth in wealth, comfort, largely of the happiness of the world now familiar to us.

The great inventor founded a prize at the University of Glasgow in 1808, as he said, "to excite that spirit of inquiry and exertion among the students of the college, which appears to me the more useful, as the very existence of Great Britain as a nation seems to me, in great measure, to depend upon her exertions in science and the arts"—a spirit which his own work illustrated in supreme degree.

It is that spirit, quite as much as real knowledge, which the school should stimulate and supply. The right spirit being awakened, all the rest follows inevitably.

Supplementing the study of the mind and its products—the ancient learning—by the study of nature

* An address delivered before the Virginia Mechanics' Institute, Richmond, Va., in the hall of the Young Men's Christian Association, May 18, 1894.

and her laws, with a view to their application to the promotion of the best interests of the world, the advancement of every highest faculty and purpose of the race—the characteristics of modern learning—the scholar of to-day finds at once the most attractive and engrossing fields of work and the most fruitful departments of intellectual labor.

SUPPLEMENTING THE SCHOLASTIC.

In our day the colleges and the schools are doing more than ever before to advance the best interests of the race. They are supplementing the purely scholastic and intellectual gymnastic curriculum of the middle ages with the applied science and special instruction needed by a nation of workers.

The older schools taught not the sciences, the literatures and the arts of their time, but mainly the literatures, and those almost exclusively "classic;" our schools are coming to give to all who desire them the principles of all literatures, all sciences and of all arts, the outgrowth of all history, the most complete and perfect education of the time.

We may now ask: What is the purpose and the method of the education which it should be the privilege of every citizen to enjoy? Why should the child be given its primary instruction, the youth his schooling in higher learning, the young man or the young woman, when practicable, a college education? What studies should child and youth and mature man or woman take up? What should be the aim and the way of securing the right kind of education? Should not education, in all cases, be directed toward the preparation of the individual for making the most of the probable after-life? Should it not prepare him for, first, taking care of himself in the world; next, for the safe maintenance of his family; next, for the enjoyment of the moral and intellectual pleasures of whatever social existence may be fairly anticipated for him? These are the thoughts that took shape in the minds of great men of earlier times, like St. Basil, of Cæsarea, who opened workshops for the "tramps" of the time; like the founders of Alexandria and its first of all universities; like Martin Luther, who insisted that the humblest citizens should be taught those branches of knowledge most needed by them and most useful in their daily life and work; like John Locke, who eloquently condemned the useless methods of education of "the cloister period" of the "dark ages," and urged as earnestly and effectively the institution of systems of instruction in the branches of current knowledge which best serve the man in daily struggles with poverty, illness and crime, which give him the greatest advantage in the life which he is to lead; like John Milton, who never ceased his invectives against, on the one hand, leaving a people in ignorance, and on the other, teaching the wealthy and leisure classes only gymnastic forms of education.

Those mighty intellects long ago thought out what is but now coming to be the system of general education of the people of a nation for their life and work. Count Rumford, a century ago, established, for the benefit of the beggars of Bavaria, a Miltonian system of instruction. The nations of the earth are just doing as much for their worthiest citizens.

AN ANCIENT STEAM ENGINE.

The Marquis of Worcester is famous as the inventor of a steam engine two centuries ago; but his grandest efforts were toward the institution of schools of applied science for the people of Great Britain. We remember Descartes as a wonderful mathematician, a great philosopher; but the best evidence of the power of his logical mind and of his philosophical attainments is found in his advocacy of schools for the people, to teach the useful knowledge desired and needed by the people.

John Scott Russell was a great ship builder and naval architect—and a statesman—but his grandest claim upon the respect and the gratitude of the world lies in his splendid work in promotion of the technical, the practical, education of the English people, and the best evidence of his greatness as a statesman is to be found in what he has written in his remarkable book of that subject, with its eloquent appeal to his sovereign in favor of the direct and active employment of all royal power and influence in the promotion of this, the greatest of all great people's causes.

All the world is now beginning to understand this mightiest of the world's great problems, and in every country may now be seen the development of the newer education.

NEWER EDUCATION.

This newer education, which has simply grown, by a process of steady and perfectly natural evolution, out of the old, endeavors to give to every one the extent and kind of instruction which will best fit him for his future life and work, and for fullest enjoyment of its later years, which should be years of comfort and leisure. It gives instruction in the essentials of all preparatory learning—substantially the "three r's" of our fathers—follows it with the natural sequence of common school studies, but incorporates into the older system the manual training school, the trade school, and the schools of engineering and of other technical branches. The study of science is thus accompanied by the application of such knowledge to the better preparation of the student for doing his work in life. He is given not only intellectual knowledge, but skill in the use of tools; not only scientific education, but a good, professional training.

As some one has said in similar connection, and the observation never loses its force, though it may seem trite enough, that "The cheerful worker is the happiest of men, the idle man the most miserable. He who makes something grow where nothing grew before, he who makes something useful to man which did not exist before, is the true benefactor of his race." And this is the privilege of the mechanic in every department. Happy in his work; fortunate in its outcome; contented because he is busily engaged through the working hours; satisfied that his work is producing the most needed forms of product; that it is at the same time giving him assurance of comfortable support for himself and family; the skilled mechanic is, on the whole, probably the most fortunate and happy man on the face of the globe. But his success and his happiness depend largely upon, not simply manual skill, power to handle tools and to give correct form or fine finish to his work, but in highest form on a familiarity with science, mathematics and the laws of nature; with the nature, source, methods of preparation and of utilization to best advantage of the materials of construction; with the principles of strength of materials; with the methods of design, of giving form and correct proportion to parts, with the best construction of machines as wholes; with the latest and most scientific methods of design, construction, operation and of tests of effectiveness; with, to put the matter in a word, the methods which lead to the attainment of the prescribed end in the best way and at the very least cost of continuous operation.

Young men and young women, as well, to-day seek earnestly the way to self-support, and to a higher life than that of the mere droning worker on monotonously repeated tasks, and the secret of success is seen by the most intelligent to be discoverable only along those paths of study and practice which add to simple skill a real knowledge of the sciences. Physics, and especially the sciences of heat and electricity; chemistry, and especially the chemistry of common life and of the processes of manufacture; knowledge of all natural sciences and of the fundamental laws of control of nature's great forces; mathematics and artistic and workmanlike drawing; these are the subjects of primary importance to the young mechanic, whether in man's or woman's fields of labor. Every great inventor, all great discoverers, have found the secret of success in life, and the real philosopher's stone, by delving deep in the secrets of nature.

Look back upon the history of modern progress; study the lives of those who have made new blades of grass to grow; who have provided their fellows with the means of advancement; who have made the world of the nineteenth century so much broader, higher, and better than that of the dark ages, and observe where their talents found opportunity and how they were led into the paths of personal success and fame. One century has seen more of real progress than the race had witnessed before in its whole lifetime; and this has come of the application, by the inventor and the mechanic, of the facts and laws of physical science to the useful purposes of their lives. Read the works of Smiles, of Dircks, of Arago, of any of the biographies of the great inventors and discoverers, and see how universally true is this statement—then "go and do likewise."

Newcomen invented the steam engine in its modern form, and Watt gave it its essential refinements, and by his inventions supplied the world with the power of steam—displacing mountains, organizing mills in which are utilized the power of thousands of giants, propelling the locomotive and its trains of palaces across the country at the rate of fifty or even a hundred miles an hour, and driving great steamships over the ocean amid the heaviest gales and among the mightiest of seas, traversing the waters at a higher rate of speed than can be attained by the fastest horse drawing the lightest carriage on the land. The work of the world is performed by James Watt's steam engine.

James Watt made the modern world; he accomplished his almost miraculous task by simple applications of the most familiar of the laws of physics and of chemistry. He was born in humble life; was weak and out of health throughout his whole life, though living to the great age of eighty-four. But his feeble energies were applied from childhood to the acquisition of knowledge of the laws of nature; his mind sought knowledge and drank it in as the sponge absorbs water. He made himself a good mechanic and a wise man, and combined the two, the highest of human endowments, to the great task of harnessing the powers of fire and water for the use of mankind.

He was a mathematical instrument maker at the University of Glasgow, a little more than a hundred years ago. There he studied the construction of Newcomen's crude invention, saw its defects, and made good use of his studies for its perfection.

Even his method of invention—if we choose to call it such, for in these days we should call it scientific design—was a scientific method of application of science to a defined and well understood task. He not only ascertained the defects of the Newcomen engine; he sought out, by exact and carefully devised experimental investigation, the origin and magnitude of each. He adopted equally scientific methods of correcting those defects. He measured the weight of steam used and of that wasted by the old engine; he ascertained precisely where these wastes of steam originated; he found their cause. Then his science taught him just how to remove that cause, and his simple dictum, "keep the cylinder at all times as hot as the steam which enters it," has been the guiding principle of every improver of the efficiency of the steam engine from his time to the present, and his scientific investigations and their deductions have constituted the basis of all later improvements. His studies when a child and as a youth, and his scientific investigations as a man, gave James Watt fame and fortune, and elevated the whole world to a higher and more permanent prosperity.

George Stephenson gave us the locomotive, but "Geordie" was not a simple droning plodder. He was a poor, uneducated colliery lad, endowed, however, with an unconquerable ambition, habits of industry, fondness for learning, and especially a determination that his work should be done as well as he or any one else could do that work, whether it were picking over refuse coal at six pence a day, or building steam engines, and receiving a princely income. He began to learn to read when eighteen years old; he studied arithmetic at nineteen; he was a man before he could even begin to acquire that knowledge from books which is freely offered most of us at the very threshold of life; but he was a wise man at thirty, a learned man at fifty, a man of the world and a prince among men from middle life on to the end. He supported a wife and child when hardly beyond legal manhood by "tending" a colliery engine, shoe making at odd times and mending his neighbors' clocks in spare minutes. But he still found time for thought and study and experiment and invention. No hour or minute was lost. "The whole secret of Stephenson's success in life was his careful improvement of time; this is the rock out of which fortunes are carved and great characters are formed," says one of his biographers. "Patience is genius," and labor constitutes the most effective prayer. George Stephenson applied genius and labor, gave patience and prayer to his work. He studied the construction of the steam engine, sought out the scientific principles upon which its operation was based; he applied his science and his mechanic's art to the application of the science and the adapting of the machine to a new purpose and brought out the locomotive—that most marvelous of all forms of concentrated power and speed yet born of the brain of the inventor and mechanic—and this mighty engine bore him on to fame and fortune.

George Stephenson did honest work; he was conscientious in his dealings with men; he made himself learned in the sciences of his time in spite of every obstacle of birth, circumstance or fate; he worked, he studied, he thought and contrived; he "hustled while he waited," as one of our great railroad men would say, in language amply expressive, if not elegant. As he himself said, when endeavoring to secure a grant from Parliament, "I put up with every rebuff; I was determined not to be put down." Stephenson's locomotive, the Rocket, made nearly 25 miles an hour, the prize record, at the Rainhill competition on the Liverpool and Manchester Railway in 1829; and now, but two generations later, we have in the United States alone two hundred thousand miles of railway, traversed by forty thousand locomotives, built upon substantially the plans of Stephenson, of sixty years ago and more. A barrel of flour or a ton of coal is carried by them a thousand miles for the value of the equivalent quantity of wheat in the fields of the far West, and the subsistence of a family for a year may be transported from Dakota to Baltimore for ten dollars. A half ounce of fuel will carry a ton a mile on the ocean, and a half cent will pay for equal transportation on land; thanks to the genius of Watt and Stephenson and their successors.

Fitch and Stephens in this country, Taylor and Symmington in Great Britain, applied the power of the mist giant to the propulsion of steam vessels hardly a century ago; Fulton and Bell carried the invention of these great mechanics to commercial success a little later. All were men combining more or less thoroughly the skill of the mechanic and knowledge of physics and chemistry; of the laws of nature with the genius of the inventor.

Benjamin Franklin, a poor chandler's boy, without schooling, but thirsty for learning, wandering from Boston to Philadelphia to seek for work at his trade of printer, makes of himself, through the most insignificant of opportunities, apparently a man learned in arts and philosophy, and acquires fame as a statesman. At fifty years of age he finds time to take up the study of natural philosophy, and by his experimental investigations proves the nature and source of the lightning. Wheatstone and Morse, familiar with the principles of physical science, find ways of diverting the lightning to useful purposes and construct the telegraph, giving communication over land and under sea, between nations and continents; belting the earth with an electric girdle, pulsing with intelligence and binding nations in a common life. Through study and experiment later inventors have made electricity the servant of steam, and by application of the laws of science, utilize this wonderful and mysterious form of energy in lighting a city or operating a railway, applying the power of the prime motor to a thousand tasks miles away through a thread of wire.

Scientific knowledge, though ever so elementary, is the key of all great treasure houses in our time. What James Watt knew of science is taught to-day to the child of fifteen in our public schools; many a school boy knows more of the laws of heat and the action of steam than did George Stephenson; and the learning of Franklin and of Morse is commonplace to the bright student of our day. But they worked in a then new field, and we must find other and newer and more obscure ranges for our explorations.

THE TELEPHONE.

That most wonderful, most Aladdin-like of all modern inventions, the telephone, of Prof. Alexander Graham Bell, is the outcome of pure scientific knowledge of electrical physics, and is the product of the active brain, not of a skilled mechanic, but of a student of nature, simply; possessing, no doubt, the divine genius of invention, but a scholar rather than a mechanic, nevertheless. To-day this marvelous annihilator of time and space spreads a network of a half million miles of wire over the United States alone, employs 600,000 instruments, allows a quarter of a million of people to talk with one another at distances of miles, of a thousand miles, if needs be, and as easily as if face to face. Who knows but that some one of our inventors—America is famed throughout the world for their successes already—may yet bring these friends to see each other face to face, though a thousand miles apart, or separated by the broad Atlantic? Three thousand inventions relating to telephony are recorded in the U. S. Patent Office already; it would be remarkable if such an army of inventors should not succeed, in time, in wresting from nature every secret possibility.

But a great secret will not be revealed to the man who simply sits down quietly awaiting inspiration; it will come to him who gives night and day, time, thought and labor, to the study of the laws of nature and the already discovered facts of science, and who, by learning what has been done in the past and all known ways of application of physical science to useful purposes, shall come to see further than has any one yet into the darker field of future invention.

The coming inventors in this direction are students and thinkers, as well as mechanics. Our opportunities are greater, by far, than were those of the men who have made applied science the foundation of modern life, and we may learn more than they, and easily, where they worked toilfully; the fields of science have now been vastly more completely explored and methods of instruction have been as greatly advanced as have the methods of acquisition of learning. No one entering upon the task in the right spirit, however poor and however hard pressed, can fail to-day in an earnest and conscientious endeavor to learn the principles, facts and laws of science; but, while all may become more learned than any of those great men, few can confidently expect to attain equal eminence. The richest nuggets may have been picked up already. Yet, it remains the fact that scientific knowledge will always constitute the essential foundation of highest success

in all departments of invention and constructive art. Much is given us; much more will be demanded of us.

The ambitious youth will always, as now, seek to become familiar with mathematics and physical science; to make himself a good draughtsman; to learn the principles of designing and the best forms of machines and of their elementary parts; to know the best methods of manufacture and the newest and most economical processes of the useful arts.

Continually, we may anticipate, opportunities of acquiring knowledge will improve, while the necessity of hard work, of steady application, of application of the individual talent in its very best and most promising direction, will as steadily increase, if advancement and distinction are to be gained. The ways of life are becoming more and more crowded with a more and more rapidly moving mass of humanity, and he who would take the lead must continually exhibit a greater and a greater superiority to a constantly improving multitude. He who is content to move with the great body of later travelers will, perhaps, lead a happier life and enjoy a more satisfactory return, on the whole, for time and strength expended; his lot will certainly continually improve with the progress of the world in all its multifarious departments of science and of art.

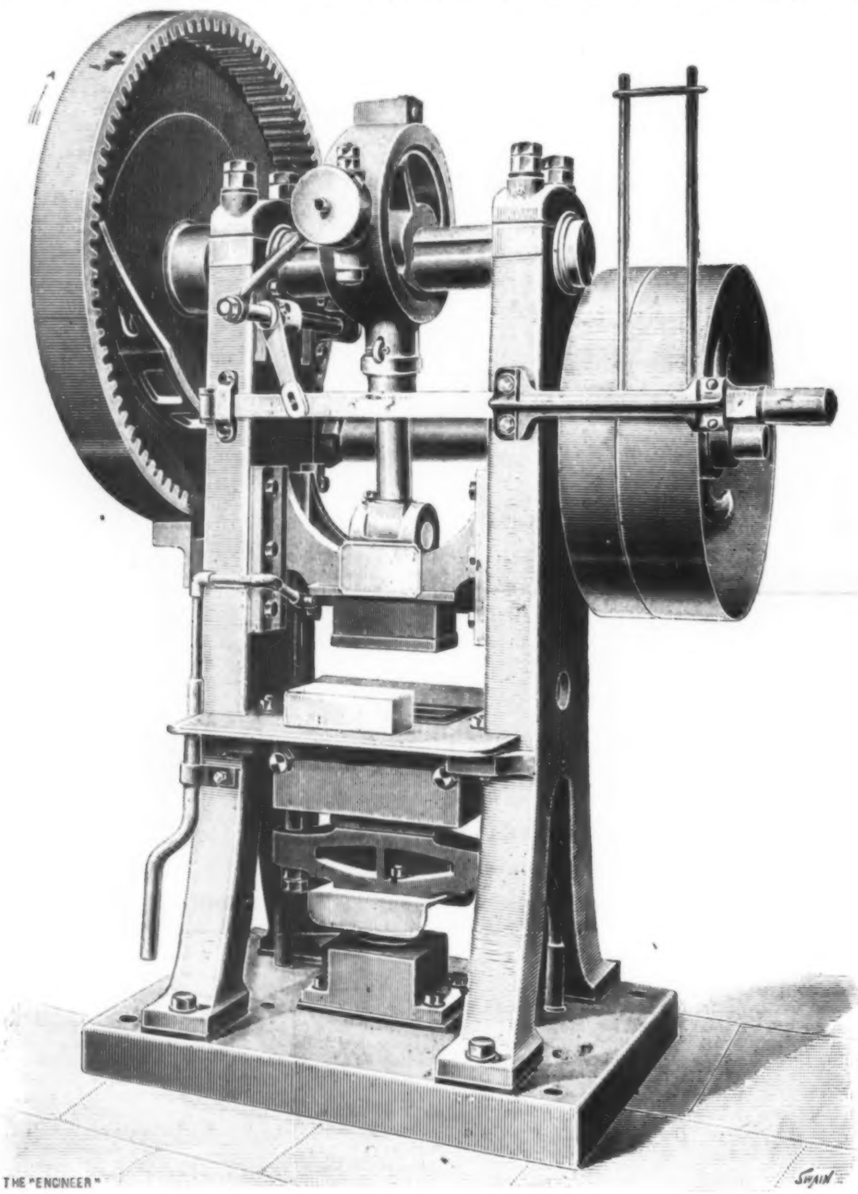
INDUSTRIAL ARMIES.

But that progress will come of the work, mainly, of the inventor and of the organizers of our "Industrial Armies." These captains and generals of the great army will be men who have added to natural ability in their special departments of activity a good knowledge of the science as well as of the art finding application in their work. Their characteristics will be intelligence, strength, ambition, courage, skill, learning in science, pure and applied, and steady application of this learning and their own talent to the purposes of their life and work. The way is open to all; none can be denied admission to the ranks, and none can be refused deserved promotion. The poorest have equal rights with the richest; and it has usually been the poorest who have accomplished most, have most advanced the work of the world, and who have, in the end, profited most by such a combination of character, learning, and skill as we have seen illustrated by the great inventors whom I have named; all of whom were poor, all of whom gained their learning and their fame with no special advantages of wealth or social position.

The civilization of the nineteenth century is the work, mainly, of men who began life in hovels, in cottages, and in the humblest walks in society; who lived in dwellings often floored with earth and roofed with straw; having neither beds nor chairs, tables nor carpets; having no schooling or social advantages; but they were men who made themselves wise and masterful in spite of circumstances, conquering difficulties more terribly repressive than the poorest to-day can realize. The youth of our day are to relay the foundations of the nineteenth century, and it is they who are to perform new wonders, to invent, to construct, to make use of all the machinery of that most marvelous of eras of which we are still merely upon the verge. They begin where Watt and Stephenson, and Fulton and Stevens, and Evans and Fitch, where the inventors of the steam engine, the railway and steamboat, the telegraph and the telephone, left off. The most defective education of our time is better than the best they could attain; the advantages of these newcomers upon the stage of action are as wonderful as has been the progress of which they are the outcome. The mechanics and engineers of the last century have given the youth of the present a glorious start; have provided them with marvelous facilities for further advancement; have put them face to face with new and still grander problems; have given them unimaginable opportunities. These opportunities may be availed of by any young man or woman who chooses to put life and strength and talents into the task with steadiness, conscientiousness and persistence. No one so poor, no one so obscure, that opportunity cannot be found. Work and think; study and improve; train mind and body continually—success is sure to come at last.

IMPROVED BRICK AND TILE PRESS.

MESSRS. BRADLEY & CRAVEN, Wakefeld, England, have just brought out a new steam power brick and tile press, of which we give an engraving from the Engineer. The internally geared wheel on the press shaft is fitted with a cam or inclined plane; this comes in contact with the end of the bar carrying the belt guide forks at every revolution, and shifts the belt on to the loose pulley. The wheel has an adjustable balance weight to overcome the momentum of the wheel and stop the eccentric when it gets to the top of the stroke, or before the crosshead has commenced its downward stroke. The piston being stationary with the eccentric at its full stroke, there is no danger of the attendants getting their fingers caught in putting in or removing the bricks; the press cannot start again until a lever on the belt guide bar is operated. If desired, however, the press can be made to start automatically in the following manner: The spur wheel has in this case a longer inclined plane or cam; this cam knocks off the belt at the given time and place, but the momentum of the wheel carries it until the inclined plane passes the end of the belt guide bar, and by placing a weight on the starting lever the leverage of this weight moves the guide bar and the belt is put on to the fast pulley, and work is carried on with only a slight pause when the belt is on the loose pulley during the time the guide bar is traveling over the inclined plane in the wheel. The press is in daily operation at the makers' works.



IMPROVED BRICK AND TILE PRESS.

NEW PROCESS FOR THE ELIMINATION OF SULPHUR FROM IRON AND STEEL.

THE practical application of the use of lime to desulphurize pig iron in cupola furnaces, as tried at the works of Williams & Clapp, is described by a correspondent of the London Iron and Coal Trades Review, who says that this firm has had the process in operation at Newport, Wales, where an effort has been made to provide a satisfactory mechanical mixer to bring the pulverized lime into contact with the molten metal as the latter is passing from the bottom of the coke bed to the hearth of the cupola furnace. Mr. John Parry, of Ebbw Vale Steel Works, tested the process and reported as follows:

"I find the fundamental idea of utilizing the immediate presence and direct force of the blast itself for conveying the purifying agents into the furnace is not only entirely new in practice, but in theory perfectly sound and good, as it is everywhere admitted—and indeed, needs no argument to show—that the nearer you get to the primary stage in the manufacture of iron as regards the introduction of any purifying agent, the more economical the whole process becomes, just as it is known and admitted that after processes—that is, after the iron has left the blast or cupola furnace—cost, as a rule, too much to permit of their adoption. I find that you propose to use simply lime alone. This is a very wise suggestion on your part, as lime, which is found so abundantly in nature, is necessarily one of the cheapest ingredients that could be possibly made use of. I would here point out that a process by Mr. Saniter, of Wigan, proposes to use a mixture of lime and chloride of calcium, which process, however, only applies to the treatment of iron after it has left the furnace, and I estimate this must cost at least 1s. per ton, and this is considered too dear to admit of any very large adoption. In this opinion I am supported by the remarks of Sir Isaac Lowthian Bell at the meeting of the Iron and Steel Institute at Liverpool."

Mr. Parry and Mr. E. F. Dewdney recently made some experiments with this process at Cardiff, in an ordinary cupola, which was first charged with 5 cwt. of cinder pig, containing about 0·90% of sulphur, together with Glamorganshire coke in the usual proportions. This coke was not analyzed, but it contained probably about 0·75% of sulphur. The iron was then run out, and it presented the usual appearance of cinder pig when cast. A small quantity of limestone had at the time of melting been put into the top of the cupola as usual. They next charged 5 cwt. of the same cinder pig with the usual proportion of coke, limestone, etc., and then commenced the process of loading the blast with lime in a powdered state. This went on continuously throughout the whole process, about 6¼ lb. of lime in a coarse powder—i. e., ordinary ground lime—being used. They continued blowing in until the iron was melted down, which occupied about half an hour. At intervals during the experiment they watched the progress of the lime through the tuyeres, and found that it was freely and regularly injected into the furnace. There was no approach to gobbing up, and they could see distinctly the particles of lime, as carried in by the blast, impinging upon the molten iron as it trickled down in fine streams through the coke. The heat at the tuyeres remained at the normal degree, there being apparently no reduction of temperature due to the blowing in of the lime or any tendency to the formation of scaffolding, which it was thought might occur owing to the infusible character of the lime. All the lime appeared to diffuse itself right through the furnace, and the characteristic lines of calcium as given by spectrum analysis could be plainly seen in the flame at the top of the furnace. The iron was then run out and presented a very different appearance from the previous charge of the same pig. It was much thinner and more fluid and appeared to be at a higher temperature than the previous cast, and it also had the peculiar surface film of fairly good gray iron. The iron was run into a ladle and cast in the usual moulds. The men at the foundry directed attention to the strong effervescence or bubbling of the iron, which continued for a long time after it had been drawn into the ladle and run into the moulds.

The iron cast the second time was, in the decided opinion of all concerned, of a very superior character, and was apparently due solely to the blowing in of the lime. Samples were taken of both the first and second casts. The first cast possessed all the usual characteristics of hard cinder pig, altogether unworkable with tools, and although a steam drill was tried upon it no progress could be made as regards drilling. The sample of the second cast was soft, tough, and easily drilled by even a hand drill, and the drillings came out something like those in common gray iron, and very unlike those producible from white cinder pig.

On analysis, the purified iron was found to contain 0·92% of sulphur, from which it would appear that the iron had not been desulphurized, but rather that a change had been brought about in its physical character. There is not the least doubt that the reason why some percentage of sulphur was not eliminated was because the quantity of lime used was altogether too small, as at least ten times the quantity should have been employed for this particular class of iron, having regard to the fact that cinder pig is well known to contain such a large percentage of sulphur. In summarizing the results of this their first experiment with the new process, Messrs. Parry and Dewdney set out their conclusions as follows:

1. That it is mechanically practicable to load the blast automatically with lime in a powdered form, without any reduction of temperature or tendency to gob up the furnace.

2. That the lime by being so loaded in the blast can be made to permeate the whole contents of the furnace, and thus be equally distributed throughout the charge, thereby exerting a full chemical condition thereon.

3. That the quantity of lime blown in was insufficient to produce any appreciable effect in the direction of eliminating the sulphur; nevertheless, the quantity of lime blown in, small as it was, must have had the effect of fluxing away the silica from the iron, thus leaving little or nothing of the lime for reaction upon the sulphur, seeing, as already stated, ten times the amount of lime ought to have been used. The

effect, however, upon the iron was to make it softer, tougher and of malleable quality, thus being considerably improved.

The result of this preliminary test, it is stated, shows that comparatively worthless pig iron may be converted into a merchantable iron fit for best quality castings. In confirmation of this, it may be mentioned that the whole of the charge made in this experiment was used for castings required in some new hydraulic machinery for the Bute Dock Company, and although they were not asked to give any report, the engineers engaged in that undertaking volunteered information to the proprietor of the foundry that the castings were the best they ever remembered to have had.

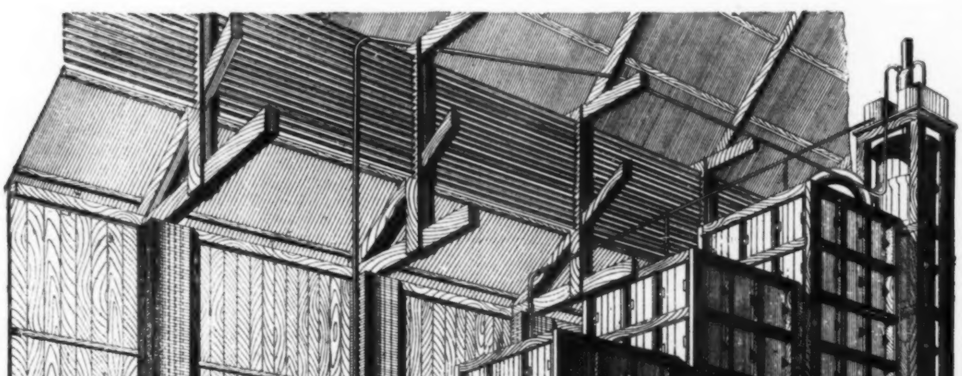
ECONOMIC MANUFACTURE OF SULPHURIC ACID.

THE industrial manufacture of sulphuric acid dates from 1746, the epoch at which the English chemists Roebuck & Garbett conceived the idea of effecting the combustion of sulphur in the presence of saltpeter in large chambers lined with lead.

The first installation at Birmingham having given satisfactory results, a second was made at Prestonpans.

A little later on, in 1766, an engineer of English origin, Holker, established the first French sulphuric acid manufactory at Rouen. The process was improved in 1774 by Mr. De la Folie, who conceived the idea of introducing steam into the chambers in order to increase the rapidity of the reactions.

In 1827, another very important improvement was introduced by Gay Lussac, who replaced the use of saltpeter by that of nitric acid, and arranged in the train of the chambers a coke tower with a sprinkling of



ARRANGEMENT OF THE APPARATUS FOR MANUFACTURING SULPHURIC ACID BY THE BARBIER PROCESS.

sulphuric acid for the purpose of regenerating the nitrous vapors escaping from the reactions. These innovations have contributed in a large measure toward diminishing the cost of manufacture.

Finally, in 1859, Glover established at the Washington Works, in the County of Durham, England, a special tower, interposed between the sulphur furnaces and the chambers, and designed to denitrate the impure sulphuric acid and at the same time concentrate it by the utilization of the heat of the sulphurous gases coming from the roasting furnaces.

The Glover tower, which was much criticised at first, was not introduced into the works of the Continent until twelve years later. It has now become the obligatory accompaniment of all lead chambers.

Up to 1832, sulphur was exclusively used in the preparation of sulphuric acid. At this epoch, Mr. Michel Perret, of Lyons, devised a special furnace for the roasting of pyrites. This furnace, which was for a long time the only one in use, is now replaced in almost all the French manufactories by what is called the Maletra furnace.

In Germany the pyrites are still roasted in kilns.

For the roasting of blendes, the Hasenclever, Eichhorn, Liebig and Vieille Montagne furnaces are employed.

Since the addition of the Gay Lussac and Glover towers to the chambers, all the improvements that the latter have received are merely those of detail.

Meanwhile, the tentatives made with the object in view of replacing so cumbersome and so costly apparatus by simpler, and especially by cheaper ones, have been numerous.

As the reactions that determine the formation of sulphuric acid necessitate the incessantly renewed afflux of great volumes of air, steam, and sulphurous acid, it has always been considered an absolute necessity to employ vast spaces for their reception; but, by very reason of such great capacities, the reactions can be effected but slowly, since there is never a uniform mixture of the gases, and the latter meet, so to speak, no obstacles or friction surfaces capable of bringing about intimate contacts.

It is at a few rare points only that friction or impacts occur, and it is at such points precisely that the formation of the acid is the most active. It is, for example, at the moment at which the gases enter the chambers or when they impinge against the surface of the liquid that covers the bottom, and it is especially in a very limited section of the Glover, at the meeting point of the gases that enter at the top and bottom of the tower.

An apparatus that would cause such impacts and meetings in a continuous manner and at all points of the travel would undoubtedly realize the problem of the economic manufacture of sulphuric acid and its intensive production in a reduced space.

Taking such a principle as a basis, numerous inventors have attempted to replace the leaden chambers. Some have tried to multiply the contacts of the gases with appropriate liquids, others have preferred to substitute smaller chambers for those of vast section, and others still have conceived the idea of transforming or multiplying the Glover towers in order to cause them to play the role of principal producer.

Thus Messrs. MacDougal & Rawson, in 1848, proposed to make the gases pass into a large number of Woolf bottles filled with nitric liquids circulating in opposite directions.

In 1853, Mr. Hunt recommended the use of coke towers with a sprinkling of nitrous sulphurous acid.

In 1855, Mr. Persoz recommended that the sulphurous gases should be passed into a series of stoneware vessels containing nitric acid kept in a continuous state of agitation.

In 1866, Mr. Fouche Lepelletier got up at Javel-Paris an analogous apparatus composed of a series of stoneware pipes and cylinders. Starting from the same principle, Mr. Vestraet superposed the stoneware cylinders in vertical columns, five cylinders constituting a column, and twelve columns being in a line with one another. The bottomless cylinders were filled with coke, the sulphurous acid entered at the bottom of the columns, and a thin stream of nitric acid was allowed to flow in at the top.

In 1873, Mr. Bernadec patented the use of towers with shelves arranged in a spiral.

The Thyss apparatus, which had a certain notoriety, consisted of ten columns alternately empty and lined with perforated plates. The gases entered at the top and the steam was injected at the base of the empty columns.

In 1885, Mr. Coignet patented a tower of the Glover type, in which the different gases necessary for the reactions were led to the upper part by four conduits. An artificial draught afterward caused them to descend through a filling of fragments of silex, coke, or slag. Jets of steam entering at different points were designed to favor the reactions. The sulphuric acid produced flowed into a chamber arranged at the base of the tower.

For the purpose of diminishing the volume of the chambers, Mr. Sorel, in 1887, proposed to place sulphuric acid columns in front of the latter. The gases entered at the bottom.

Messrs. Lunge & Rohrmann have recommended the introduction of two earthenware towers with shelves between the chambers. At the summit of these sulphuric acid at 35° B. is allowed to flow in.

In the Durand & Huguenin process, sulphurous acid and compressed air are passed through receptacles alternating with condensation columns and containing nitric waters. The object of the pressure of the air is to quicken the combustion of the sulphur, to produce an intimate mixture of the gases, and to permit of a bubbling in the receivers.

Let us mention also the very complicated apparatus of Mr. De Hemptinne, in which three large leaden chambers are filled with 5,200 superposed cylinders.

Finally, other inventors have endeavored to manufacture the acid by special processes.

For example, Messrs. Terrel, Hogg and Thomlinson, who have proposed to burn the pyrites in pure oxygen, and Messrs. Langlois and Thomassin, who have recommended the use of oxygenated water.

The various attempts to manufacture by means of the Glover tower exclusively are the most happy, but none of them has succeeded, for a reason that we shall point out.

The Glover, as well known, has a quadruple effect: (1) It removes from the sulphuric acid its nitrous products and allows them to re-enter the cycle of reactions; (2) it concentrates this same acid without additional expense; (3) it cools the sulphurous acid before its passage to the chambers; (4) it converts into sulphurous acid from 15 to 20 per cent. of the sulphurous gas derived from the roasting furnace.

This latter point is of supreme importance, since it establishes that, in a small apparatus, whose volume is scarcely 1½ per cent. that of the chambers, it is possible to obtain the fifth of the total production of the sulphuric acid.

Now, if we examine the operation of the Glover a little more closely, we shall find that this activity of production of the acid is localized toward the median part, in a very limited zone, which is at the most a tenth of the total height. It is here that is directed all the effort of the reactions between the sulphurous acid coming from the bottom and the nitric liquids entering at the top.

Beneath this zone we find no longer anything but denitrated sulphuric acid, which becomes concentrated in contact with the hot sulphurous gases. Above it is a mixture of sulphurous acid, air carried along, and nitrous products or aqueous vapors due to the concentration at the lower part of the tower, a mixture that afterward passes into the chambers in which the reactions are finished.

Those who have desired to manufacture sulphuric acid with the sole aid of the Glover tower have occupied themselves, before all else, with multiplying the number of the towers instead of trying, on the contrary, to realize in all parts of a single tower the intensive production that is observed in the median zone.

Why, in fact, do the reactions take place only in so limited a section? It is because the necessary elements are lacking. The sulphurous gases, entering the Glover with high velocity, decompose the nitric or nitrous products that come from above before the latter have time to descend.

On another hand, at a certain height, the sulphurous gases are no longer hot enough to act actively upon the nitric acid. Entering at the base of the tower at a temperature of about 300°, the sulphurous gases make their exit from it at between 50° and 75°.

Taking as a basis the various considerations that precede, Mr. E. J. Barbier has succeeded in devising an arrangement which, under a simple and practical form, realizes the long-sought problem of the manufacture of sulphuric acid without lead chambers.

His apparatus comprises pyrites furnaces and three small reaction towers interposed between a sort of Glover or denitrating tower and a Gay Lussac of special construction. These various towers are filled with small cells with perforated bottoms that present a development of from 70 to 75 square meters friction surface per cubic meter of filling.

Beneath the towers, and in communication with them, are arranged basins in ascending series that are heated directly by the hot gases emanating from the roasting furnaces. These basins receive on the one hand the dilute sulphuric and the nitric acid that falls from the reaction towers, and, on the other, the nitrous sulphuric acid that comes from the Gay Lussac tower. The apparatus operates as follows:

The roasting furnaces being in operation, the sulphurous acid and the air carried along are directed beneath the basins, where they heat the liquids of the cascade. The latter become concentrated and emit aqueous and nitrous vapors that ascend into the reaction towers.

Then the sulphurous acid, partially cooled, passes into the denitrating tower, in which is a spray of sulphonitric acid.

There is thus produced concentrated and denitrated sulphuric acid, which is collected, while the remaining gases, composed of sulphurous acid, nitrous vapors, and aqueous vapors, are directed into the first tower, which they enter through the bottom. There is an immediate reaction in the contact with the hot gases emanating from the basins, and then the sulphurous gases that have escaped this oxidizing effect meet, in ascending, nitric products derived from the nitric waters with which the top of the tower is sprayed. In this manner, the series of reactions continues throughout the entire extent. The gases, which are obliged to traverse the filling cells in measure as they ascend, whirl around in these little chambers, become mixed and move against the constantly moistened walls—all circumstances eminently favorable to the formation of sulphuric acid.

The small quantity of sulphurous acid that escapes from the first tower passes into the second and thence into the third, where the same emissions, the same contacts, and the same reactions are renewed.

Finally, the Gay Lussac tower retains the last non-utilized nitrous vapors. These nitrous products afterward repass into the towers after being expelled by evaporation from the concentrating basins.

The acid that falls from the towers into the cascades titrates about 50° B., but when it flows from the last basin it is concentrated to 58° or 60° B., and completely freed from nitrous vapors.

There are obtained from 40 to 50 kilogrammes of acid at 58°-60° B. per cubic meter of tower, while the old apparatus give no more than from 4 to 5 kilogrammes of acid at 52°-53° B. per cubic meter of chambers.

The apparatus operates between the extreme tem-

peratures of 100° and 50° C., and this permits of its being advantageously utilized in warm countries. The evaporation of the liquids from the basins and the addition of strong nitric water furnishes an ample sufficiency of vapor for the reactions. It is, therefore, unnecessary to employ a special generator of steam.

Three men suffice to run the apparatus, which, moreover, it costs but little to keep in order, since the lining of the towers is not of lead, but of acid-proof bricks, which are capable of resisting indefinitely.

An apparatus producing 1,000 kilogrammes per day occupies an area of 70 square meters, and one producing 7,000 kilogrammes occupies 100.

Finally, the cost of production of the acid does not exceed that of the acid produced in chambers. It is even less when we take into account the interest on the small amount of capital invested.

Instead of nitric acid, it is possible to employ nitrate of soda. The pans containing the soda are arranged on a line with the passage of the sulphurous gases in the conduit that precedes the first reaction tower.

The great advantage of the Barbier apparatus is its simplicity of installation and operation. It is applicable to a daily production that varies, according to the dimensions of the towers and the number of roasting furnaces, from 700 to 10,000 kilogrammes, and even more. When it is desired to obtain a very great production, each tower is preceded by a denitrator and the sulphurous gases are distributed between the various denitrators.

Although the reactions that give rise to sulphuric acid are the same as those of the lead chambers, the theory of Peligot seems rather applicable to this particular case. By reason of the high temperature of the towers, there is certainly a direct reduction of the nitric by the sulphurous acid, since the temperature of the towers is always higher than 60° C. So that the theory of the formation of the sulphuric acid may be formulated thus:

1. The sulphurous acid that traverses the denitrator is oxidized by the nitric acid; there is a production of sulphuric and hyponitric acids.

$$2AzHO^3 + SO^2 = SO^2(OH)^2 + 2AzO^2.$$

The excess of sulphurous acid passes with the hyponitric acid into the first tower, into which enter at the same time the aqueous and nitrous vapors emitted by the basins.

2. The hyponitric acid, in the presence of steam, is converted into nitric acid and binoxide of nitrogen.

$$3AzO^2 + H^2O = 2AzHO^3 + AzO.$$

The nitric acid thus regenerated oxidizes the sulphuric acid and gives rise to sulphuric and hyponitric acids.

3. The binoxide of nitrogen, in the presence of the oxygen of the air, is converted into hyponitric acid.

$$AzO + O = AzO^2,$$

and so on.

It is, therefore, the constantly regenerated nitric acid that oxidizes the sulphurous acid through the high temperature of the towers.—Revue Technique.

THE FORMATION OF SCALE IN BOILERS, AND IN FEED, CIRCULATING AND BLOW-OFF PIPES.

IF we could run boilers with perfectly pure water—for example, with water that had previously been distilled—many of the difficulties encountered in actual practice would never arise, and the fireman's duties and responsibilities would be correspondingly lessened and simplified. Unfortunately, this ideal condition of things cannot be realized. We cannot afford to use distilled water, and in most cases feed water has to be taken in accordance with that mode of selection which is known to the world at large as "Hobson's choice;" that is, we have to take what we can get. In cities and towns good water may usually be had from the city mains; but in sparsely populated districts the manufacturer has to depend upon wells or upon running streams, which usually serve as sewers for the families of the employes who live along their banks. If there is organic matter in the water, trouble is likely to result from corrosion and wasting of the boiler plates; and wells, which are notorious for the "hardness" of the water they furnish, are apt to provide the manufacturer with more scale-forming matter than he can comfortably handle. The water supply of cities is selected with special reference to its fitness for drinking purposes, and for this reason city water is usually comparatively free from organic matter. In most cases it consists of surface water which has not penetrated deeply into the soil, and which has, therefore, had but little opportunity of dissolving mineral matter; but in regions where lime and magnesia abound the city water is likely to be more or less charged with compounds of these substances, and under these circumstances it may be as "hard" as the general run of well waters, and may deposit a copious scale.

The reason why hard water is not good for use in boilers may be stated in a very few words. It is, that whatever may be put into a boiler, nothing leaves it by the process of evaporation but pure water in the form of steam. Whatever solid matter may be present, either in solution or as a visible sediment, remains behind in the boiler and continues to accumulate until it is removed by the blow-off or by opening the boiler and washing it out. A steam boiler evaporates an enormous quantity of water in the course of a year, and the total amount of solid matter deposited may, therefore, be very great, even if the water contained only a few grains of it to the gallon. This fact can be well illustrated by a simple example. Thus, let us suppose a 100 horse power boiler to be running 10 hours a day, and 300 days a year. Furthermore, let us assume that 15 pounds of water per hour are evaporated for each horse power, and that each gallon of the feed water contains 30 grains of solid matter in solution. Then the quantity of water evaporated in the course of a year will be

$$100 \times 15 \times 10 \times 300 = 4,500,000 \text{ pounds.}$$

As a gallon of water weighs about $8\frac{1}{3}$ pounds, this is equivalent to $4,500,000 \div 8\frac{1}{3} = 540,000$ gallons per year. As the solid matter present does not pass off with the steam, it must accumulate in the boiler unless it is periodically removed by blowing or otherwise. We shall assume, for the moment, that the blow-off is not opened, nor the boiler cleaned in any way, until the end of the year. Then as there are 30 grains of solid matter in each gallon of the water, the total weight of the deposit will be $540,000 \times 30 = 16,200,000$ grains; and as there are 7,000 grains in a pound, this is equal to $16,200,000 \div 7,000 = 2,314$ pounds, or more than a ton of solid matter, in the course of a year. Of course the conditions assumed in this illustration could not exist in practice, because if the boiler were not

FIG. 1.—A FEED PIPE NEARLY SEALED UP BY SCALE.

cleaned in some way, the solid matter, lodging on the plates, would protect them from the water and cause them to burn, and the boiler would be destroyed long before the end of the year. Nevertheless we have seen many boilers containing hundreds of pounds of deposit which had accumulated in this manner, through neglect, and numerous illustrative examples from such boilers are on exhibition in the Hartford office of this company.

The great bulk of the solid matter deposited from the feed water may be removed by frequent and judicious blowing. It cannot all be removed in this manner, however, for where the plates are hot, more or less of it is sure to bake on, forming the hard, stony layer known as "scale." The commonest components of scale are carbonate of lime ("limestone") and sulphate of lime ("gypsum"). Carbonate of lime seldom forms a stony scale. It may collect in large masses and do serious injury to the boiler, but the deposits which it forms are usually lighter and more porous than the corresponding deposits of the sulphate of lime. Most substances are more soluble in hot water than in cold; but carbonate of lime is a notable ex-

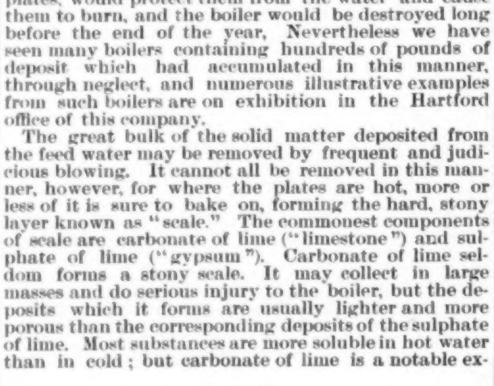


FIG. 2.—A FEED PIPE CONTAINING A HEAVY DEPOSIT.

ception to this rule, for although it is somewhat soluble in cold water, in boiling water is almost absolutely insoluble. It follows from this fact that when feed water is pumped into a boiler, the carbonate of lime it contains is precipitated in the form of small particles as soon as the temperature of the water reaches the neighborhood of 212°. These particles are whirled about for a considerable time in the general circulation, and if the circulation is good, they do not usually settle until the draught of steam is stopped for some reason—as, for instance, in shutting down at night or in banking the fires for the noon hour. The best time to remove this sediment by blowing is, therefore, just before starting up at one o'clock, or after the boiler has stood idle for an hour or so at night, or just before beginning work in the morning; for at these times the carbonate deposit has settled into a kind of mud at the bottom of the boiler.

Sulphate of lime differs from the carbonate in being more soluble in hot water than in cold; and it is,

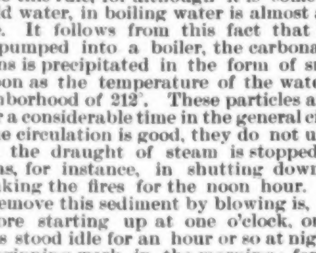


FIG. 3.—A FEED PIPE CHOKED WITH A STONE-LIKE SCALE.

therefore, not deposited in the same way. The sulphate deposit is formed at those points where the evaporation (and consequent concentration of the solution) is most rapid—that is, in contact with the shell, the tubes, and the back head. Being deposited practically in contact with the iron, it forms a hard, adherent coating, which often resembles natural stone so closely that nobody but a skilled mineralogist could tell the difference between them. The best way to treat water containing sulphate of lime is to convert the sulphate into carbonate, and remove the carbonate thus formed by means of the blow-off, as already described. This can be done, without injury to the boiler, by the use of soda ash, which is a crude carbonate of soda. The chemical action that takes place may be briefly described thus: Carbonate of soda and sulphate of lime act upon each other so as to produce sulphate of soda and carbonate of lime. The sulphate of soda thus produced is what is known in commerce as Glauber's salts. It is very soluble in water, and passes away readily through the blow-off.

A great deal has been published, in the engineering journals, about scale in boilers, and yet very little has been said about the accumulation of it in feed and blow-off pipes. There are mechanical men who maintain that scale cannot accumulate in pipes in which the water is circulating constantly, or nearly so, as in the case of feed pipes and external or internal circulating pipes; but the cases cited and illustrated in this article will show how fallacious such opinions are. As a matter of fact, these pipes often fill up in a remarkable way, the deposit choking them to such an extent that it becomes a source of positive danger. In Fig. 1, for example, we show the end of a feed pipe which had become so choked with scale as to be practically sealed up tight. The concretion in this case consists chiefly of carbonate of lime, and, after what has been said of the properties of this substance, the way in which the state of things here shown came about will be readily understood. The feed water, becoming heated by the steam and water in the boiler, could no longer hold its carbonate of lime in solution, and it was precipitated as described above. Most of the carbonate thus precipitated passed into the general circulation of the boiler in the usual way, but some of it adhered to the end of the feed pipe, and the deposit thus begun continued to collect until the state of things shown in the cut was the result. This pipe is an inch and a quarter in diameter, internally, and it was stopped up by the deposit until only a small triangular hole was left, the area of which is about $\frac{1}{125}$ of a square inch.

Fig. 2 shows another feed pipe in which the deposit was of a similar character, except that it extended back from the end of the pipe to a considerable distance. The history of this pipe is substantially the same as that of the preceding one. In each case the engineer in charge of the plant thought the difficulty was with the pumps, which could not be made to run fast enough to feed the boilers; and in each case investigation showed that the pump was all right, and proved that the trouble lay in the feed pipe.

The deposit in the pipe shown in Fig. 3 was of a different character. It was solid, stony, and fully as hard as granite. This pipe was originally an inch and a half in diameter internally, but it had become so filled up that the free opening at the end shown in the cut was reduced to a sort of rectangular slit an eighth of an inch wide and less than half an inch long. The sectional area of this slit is estimated to be 0·07 square inch, and as the original sectional area of the pipe was 1·77 square inch, it is easily seen that the effective area of discharge was reduced by the deposit to less than one twenty-fifth of the area intended by the builder of the boiler.

The most troublesome form of scale is deposited in pipes that are exposed to the fire; for in such cases the heat causes the sediment to "bake on," so that it can be removed only with a cold chisel. Blow-off pipes are particularly liable to this trouble because there is no circulation in them, and the sediment that is sure to settle there is directly exposed to the heat of the fire. To avoid the difficulty so far as possible, the blow-cock should be opened at least once a day, and where the water is bad it should be opened three times a day, if only for a few seconds. This will keep it fairly free from deposit, and in a great measure prevent it from burning. (Coverings, or sleeves, are often fitted to blow-off pipes to protect them from the fire. See The Locomotive for September, 1891.) We have often called attention to the importance of using plug cocks on blow-off pipes—or, at any rate, valves whose opening is straight, and equal to the full diameter of the blow-off pipe itself. If this precaution is neglected there is a liability of fragments of scale lodging in the pipe in front of the valve, and these may cause an accumulation of matter sufficient to stop up the pipe and allow it to burn.

We have spoken, thus far, only of feed pipes and blow-offs; but what we have said will of course apply to water grates, coil heaters, and water tube boilers generally, with a force varying according to the quality of the feed water, the design of the apparatus, and the degree of intelligence with which it is used. For example, we have seen the four inch tubes taken from water tube boilers, that were almost entirely filled with a hard, sulphate scale. The deposit so formed may protect the tubes and connections from the water to such an extent as to allow of overheating and burning, giving no end of trouble from the failure of sections and headers and other parts. As an illustration of what may happen in this way we will quote from a report recently received from one of our inspectors, concerning a certain feed water heating device in the construction of which a number of tubes are used. The device was put in operation on August 22, and for four months was thoroughly blown out every six hours. "On December 17, the header uniting the 2 inch and 4 inch pipes in No. 3 boiler stripped the thread, blowing the fire, part of the grate bars, and a few fire brick into the room, but fortunately injuring nobody. I had the coil repaired and instructed the fireman to blow out every four hours. This coil had some scale in it, but it was not badly choked, so far as it could be examined. On December 21 the fireman reported the coil on No. 5 to be red hot at the junction between the 4 inch pipe and the back connection. I had the fires drawn and the coil and boiler were examined. The boiler was perfectly clean, but there was considerable scale in the pipe leading from the coil to the boiler. This was cleaned as far as possible, and the boiler was started again. On December 22 No. 3 boiler ruptured through one of the 2 inch coil pipes. We then decided to remove the coil. We had to cut the fittings to get it out, and we found the fittings and the pipes near them to be nearly filled with scale. On December 27 the coil on No. 4 boiler burst in the same way as No. 3. We then began to remove all the coils;

but on December 29 No. 5 failed by breaking a fitting, and on December 31 No. 7 ruptured a pipe. At the present time [January 23], I have had all the coils removed except that on No. 10, and have found in all that the 2 inch pipes and fittings are badly choked with scale, some of them being almost completely filled. Until September we used nothing but artesian water; but since then we have used from 10 per cent. to 20 per cent. of river water." [The river water contains about 24 grains of solid matter per gallon, chiefly lime and magnesia carbonates, with some lime sulphate. The artesian water referred to averages about 10·64 grains of solid matter per gallon, mostly in the form of carbonates.] We quote this case, not because we have any special animosity toward this particular form of heater, but because it is a good illustration of the trouble that may arise from the accumulation of scale in water tubes exposed to the action of heat.—The Locomotive.

UTILIZATION OF WASTE CARBONIC ACID GAS IN BREWERIES.*

THIS paper gives a historical sketch of the development of the plan (first carried out at Guinness' brewery in 1890) of collecting and compressing the carbonic acid produced in breweries during fermentation and a description of the apparatus and methods employed.

The quantity of carbonic acid evolved during fermentation is approximately equal in weight to the alcohol produced. The rapid evolution of carbonic acid begins in breweries about 20 hours, in distilleries about 6 to 8 hours after "pitching," and for some time after that the evolution is rapid and regular enough to allow the gas to be drawn off by the compression pumps without fear of drawing in air. If air is drawn into the compression pump, it can be got rid of by a special release valve. For collecting the gas the ordinary parachute or skimmer is used with raising and lowering gear, allowing it to be kept just above the head of the yeast. The level of the carbonic acid in the vat is ascertained by an ordinary collodion air balloon which floats on the surface of the carbonic acid. The collection is stopped as soon as the evolution of gas becomes slow.

The compressor used is of a three-stage type, the gas being purified after the first stage (15 lb. compression) by passing through water, strong sulphuric acid and a weak solution of permanganate of potash. For purification 100 lb. of carbonic acid require 5½ lb. of sulphuric acid, ¾ oz. of potassium permanganate and ¾ oz. of sodium carbonate. The pressure in the third stage reaches about 60 atmospheres, and from this the gas passes to the condensing coils cooled by water and is liquefied. The intermediate collecting vessel and the receivers are suspended on Salter's balances, so that the attendant can at once see when they are full. Obtained in this way, the gas has a purity of 99·5 per cent., and is odorless. The receivers or cylinders are made of mild steel and are either solid drawn or lap welded. They are tested to 3,000 lb. on the square inch, the normal filling pressure at ordinary temperatures being about 750 to 800 lb. In some tests made a year or two ago by the Scotch and Irish Oxygen Co., of Glasgow, vessels of this type filled with oxygen at 1,800 lb. to the square inch were allowed to fall 35 ft. onto iron blocks, and otherwise severely treated without damage further than bending and slight loss of shape.

The cost of the liquid gas (inclusive of labor and interest on capital) is about £3 10s., and its selling price at present about £18 per ton.

The liquefied carbonic acid is now being used for raising beer in place of the ordinary pumping engine. A reducing valve is attached to the cylinder, reducing the pressure to about 4 lb. per square in., or whatever pressure is required to raise the beer from the cellar to the tap. An air-tight connection is made to the top of the barrel, and the pressure not only sends the beer up in good condition, but is said to improve it as the level gets lower in the barrel. The antiseptic qualities of the gas and its freedom from germs also make its use preferable to that of the ordinary beer engine. Liquid carbonic acid has been found advantageous in bottling beer, beer thus bottled maturing in three days, in place of three weeks. It is also used for a variety of purposes from aerating water and bread to hardening armor plates.

The author considers, however, that one of its most important uses will be in refrigerating machines. The accompanying diagram will explain the character of

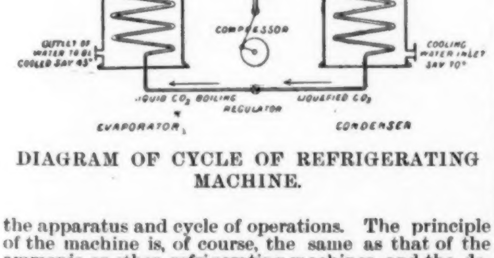


DIAGRAM OF CYCLE OF REFRIGERATING MACHINE.

the apparatus and cycle of operations. The principle of the machine is, of course, the same as that of the ammonia or ether refrigerating machines, and the degree of cooling can be regulated by the pressure under which the liquefied gas is evaporated, and it is equally easy to cool water, say from 70° to 30° Fah., or to maintain brine at say + 10° Fah. or — 10° Fah. Under 35 atmospheres pressure, for instance, liquid carbonic acid boils at 30° Fah. The surfaces of the evaporator coils are so proportioned that all the liquid which enters the lower end of the coil is evaporated by the time it reaches the top end, and thus the maximum efficiency is obtained.

It has been said that as carbonic acid will not liquefy at temperatures above 87° Fah. (its critical point), its possible duty as a refrigerant in the tropics would be very low. Experience with machines of considerable power using condensing water at 90° to 95° has, however, shown the loss of efficiency to be very slight, and 40 or 50 carbonic acid refrigerating machines are working satisfactorily in the tropics. The carbonic acid refrigerating machine has the advantage over the ammonia or ether machines that a leak is not so unpleasant or dangerous.

In the discussion, T. W. Thorpe stated that in his brewery about 1 ton 2 cwt. of liquid carbonic acid was obtained from 600 barrels of wort, and that the actual cost of collecting and compressing was ¼d. per lb., a second ¼d. per lb. being paid as royalty. In their case glass coverings over the tuns had been introduced without any deterioration of vigor of fermentation, and with increased freedom from germs. The Aerated Bread Company used their liquefied carbonic acid for raising their bread. Sir A. S. Haslam was not prepared to admit that there was no particular falling off in efficiency in the carbonic acid gas machine at temperatures at or above its critical point.

The critical point of carbonic acid is 31° C. (88° Fah.) and of ammonia 117° C. (or 232° Fah.) At 68° Fah. the latent heat of vaporization of ammonia is 540° and of carbonic acid 63°, while at 86° that of ammonia is 524° and of carbonic acid only 19°. He considered therefore that, at least at high temperatures, the ammonia machines must be more economical than the carbonic acid machines. The ammonia machine, too, only required a pressure of 90 to 150 lb. (according to the temperature of the condensing water), while the carbonic acid machines would require from 900 to 1,200 lb. pressure. He believed 1 ton of coal with an ammonia machine would do as much work as 1½ tons with a carbonic acid machine. Dr. Sykes believed the relative economy of working of the ammonia and carbon dioxide machines to be about equal.

In replying to the discussion, the author showed a curve, the pressure produced in the cylinders by increased temperature. At 113° Fah. the pressure was only about half that at which the cylinder was tested. In the tropics, where in the sun a temperature of 160° Fah. might possibly be reached, the pressure was of course considerably increased, but experience showed that even then there was practically no danger. Referring to the loss of efficiency above the critical point of the liquefied gas, he said that a large machine to make four tons of ice per day had been run for a week with the cooling water at 100° Fah. There was, of course, a loss of efficiency (as was the case whatever material was used), but it was far less than they had been led to expect). These machines were working satisfactorily in the tropics, in some places side by side with ammonia machines, so that any excessive loss of efficiency would have been at once detected.

* A. Marcet, Trans. Inst. Brewing.

PRESERVING IRON AND STEEL FROM RUST.

IN the course of a paper read before the American Society of Mechanical Engineers, the following description of the Gesner rust-proofing process is given. This process for the preservation of iron and steel is of comparatively recent introduction, and, like the Bower-Barff process, forms a coating from the metal itself that it is depended upon to protect. While the Bower-Barff process forms a magnetic oxide coating, the Gesner process claims to change the surface of the metal into a compound of hydrogen, iron and carbon, which is designated as a double carbide of hydrogen and iron; analysis of treated articles showing the presence of hydrogen in quantities from two-tenths of one per cent. and upward. This coating does not scale off by mechanical injury (articles treated can be bent cold to an angle of 45 deg. without injury), does not alter the dimensions of the articles treated, screw threads and nuts running together as freely after treatment as before; while the Bower-Barff process, when carried to the point of forming a heavy coating of magnetic oxide, materially increases the size of the parts, and has to be allowed for in fitting up of finished and jointed parts, such as hinges and loose joints. A claim made for articles treated by the Gesner process that they are unaffected in strength appears to have some foundation. The record of a number of tests made at Philadelphia on an Olsen testing machine show that the wrought iron samples were comparatively unaffected in strength by the treatment, while the steel articles showed a loss in strength of about five per cent., and a gain of five per cent. in elongation, evidently from the annealing action of the muffle. Cast iron pipe treated shows that the pores of the iron are filled and the strength materially increased. Cases reported show an increase in bursting pressures of over 100 per cent.

The color of the treated articles is a fine deep blue-black. Tempered articles, such as springs, bayonets, edged tools, etc., cannot be treated, but in some cases articles can be hardened and tempered after treatment. The process does not necessitate the use of skilled labor; after being established, ordinary workingmen are all that is requisite. The process is adaptable wherever tinning or galvanizing are employed to withstand atmospheric effects, and is materially cheaper than those methods. Among the adaptations for this process can be named: office railings, grilles, gates, wrought, cast and malleable iron pipes and fittings, steel and iron shingles, corrugated sheets for roofing, polished wrought iron pipe for bedsteads, steam radiators, builders' and art hardware, architectural ironwork, of all kinds, gun fittings, etc. These articles can be treated in small lots for prices from four and a half to seven cents per pound, and large pieces wrought iron pipe in 20 feet lengths in quantities will not cost over one cent a pound, including manufacturer's profit. One of the principal articles thus far treated is a clock tower on a storage warehouse on Schermerhorn street, Brooklyn, the clock dials of which are of wrought iron scroll work, 16 ft. in diameter. The surface of the treated articles appears to facilitate the spreading and adhesion of paint, if any is subsequently required on the structure.

The articles must be cleaned from scale to secure a good result, though the removal of oil and grease due to machining processes is not necessary. The apparatus and process of treatment are: Two ordinary clay gas retorts of any required length from 7 ft. to 20 ft. or more are set side by side with a furnace and grate below and between them, same as a gas retort setting. Suitable doors are fitted to one or both ends of the retorts as used for gas retort work. These retorts are heated to 1,000 deg. or 1,200 deg. Fah., as may be determined by the character of the articles to be treated. The articles are placed in the retorts and exposed to the heat for twenty minutes, or until they attain approximately the heat of the retort or muffle, when steam at low pressure is admitted to the inside of the retort through an iron pipe lying on the bottom of the retort, and called a hydrogen generator, which decomposes the steam, hydrogen being set free, which fills the retorts, the surplus pressure passing out by a purge pipe sealed in about 1½ in. of water to prevent ingress of air to the retorts. This steam treatment is kept up for thirty-five minutes, when a small quantity of naphtha—a pint or more—is injected by gravity into each retort and allowed to flow for ten minutes. The hydrocarbon is then cut off, and the steam which has been allowed to flow during the whole operation is continued some fifteen minutes longer. The whole time employed is therefore an hour and twenty minutes for articles of ordinary size and weight, such as builders' hardware, etc. The articles remain in the muffle sealed from air until the heat has fallen to about 800 deg. Fah., when they can be removed without danger of scaling. Ornamental objects, art hardware, etc., while hot are given a bath in whale or paraffin oil to render them even in tone, prevent finger marks, etc. The process appears to me to be almost identical with the Bower-Barff, with the exception of the use of the naphtha, which gives a foundation to the claim for the formation of a carbide that hastens the process; the time of treatment being materially less in the Gesner process than by the Bower-Barff to get the same thickness of coating. A number of plants for the working of this process are in operation in various parts of the United States, the principal one, the South Brooklyn Rust-proof Iron and Steel Works, 176 Sullivan Street, near Atlantic Basin, South Brooklyn, has a capacity of two tons daily output of small articles like builders' hardware and six tons of pipe up to 7½ ft. in length, and can treat articles up to 20 ft. in length.

ESTIMATING THE DENSITIES OF FATS.

By ZDZISLAW ZAWALKIEWICZ.

IN order to determine the relative density, at the ordinary temperature, of a fat, etc., semi-solid at that temperature, a pyknometer is used with two orifices, Fig. 1; these are connected by means of India rubber

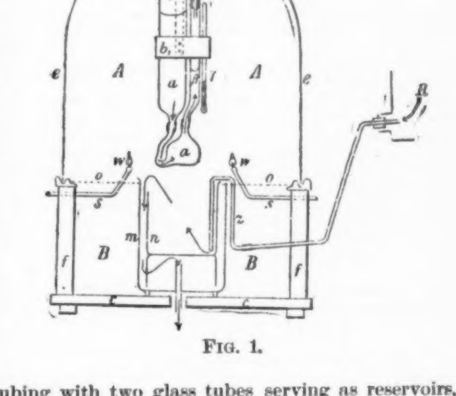


FIG. 1.

tubing with two glass tubes serving as reservoirs, α and β, Fig. 2; a brass ring, b, supports these, together with a thermometer, γ, inside a bell jar, A A, the interior of which can be heated as required by means of a series of small flames, w w. The bell jar rests on an annular support, B B, containing in its center a vessel kept full of water, passing through from the outside reservoir, R, as indicated by the arrows. To make an

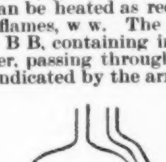


FIG. 2.

observation, the supporting rod, b_1, is raised, the larger reservoir, α, filled with the substance to be examined, and the flames, w w, lit; the material gradually melts, and descends into the pyknometer, ultimately filling it and rising up in the smaller reservoir, β, until an equality of level subsists; in this way the pyknometer is completely filled with the melted substance without air bubbles; the temperature should not be more than some 20° above the melting point of the substance. The supporting rod, b_1, is then lowered, so that the pyknometer is immersed in the water some 3 mm. deep. The cooling operation generally requires 1½ to 3 hours, the pyknometer being kept full from the reservoirs, as the warmer material contracts in volume during cooling. Finally the India rubber tubes, etc., are disconnected, and the pyknometer wiped and weighed. If P be the weight of the empty pyknometer, p that of pyknometer full of water, and p_1 that of pyknometer full of fat, the specific gravity of the fat relatively to water is $d = \frac{p_1 - P}{p_1 - P}$. Thus, samples of lanolin, yellow vaselin, lard, and butter fat gave respectively the numbers 0·95178, 0·88273, 0·94083, and 0·93175 at 16°. On examining the density of lanolin at temperatures

above and below its melting point, it was found that the rate of expansion was perceptibly greater in the semi-solid condition than at higher temperatures when completely melted; the average diminution in density per 12° rise of temperature being about 0·016 in the first case and 0·007 in the second.

THE WINTER PALACE AT THE GARDEN OF ACCLIMATION, PARIS.

To the numerous attractions that it offers visitors, the Garden of Acclimation has just added another, which is capable of competing with the most interesting; we refer to the Winter Palace, the work upon which was begun in March, 1892, according to the plans and under the orders of Mr. Emile Bertrand, architect. The inauguration of it took place quite recently.

The new edifice stands to the left of and faces the avenue that starts from the entrance of the garden, as shown in Fig. 1, which gives a general view of the structure, including the conservatory.

The Winter Palace differs from all the similar establishments existing in Europe, especially the Palmen Garten of Frankfort-am-Main, in that it includes various elements so grouped as to offer the public a covered promenade as varied as it is interesting.

At the entrance begin the hothouses, including several divisions: (1) The temperate houses, formed of three wide spans surrounded by a narrower one sheltering a walk that overlooks that of the temperate hothouses; (2) to the left and at the same level, tropical houses, each containing various species of plants and flowers; (3) in the center of these hothouses, a chamber serving as a reading room; (4) to the right of the temperate houses, a cold house in which bloom mimosas, camellias, chrysanthemums, etc., and provided with seats that to the right and left extend along a promenade. At the rear, in the great axis, stands the stage.

On the first story, which is reached by large open stairways, there is a series of overhanging benches in tiers, behind which is a gallery that permits of making the tour of the hall, in passing above the orchestra. This gallery communicates to the right and left with the promenade of the first story of the Palmarium.

Two secondary stairways lead to the gallery of the second story. This vast hall is capable of accommodating 4,500 persons, with seats for 2,000 of them, easily reached through numerous aisles.

On the ground floor, on the garden side, and widely open upon the festival hall, is situated the restaurant, from which the first and second stories are served. On the same floor to the left there is a wide entrance vestibule, with wickets for the distribution of tickets. In the vicinity of this vestibule there are two salons.

This wing, in addition, comprises, on the first and second story, vast halls capable of serving as reading and conversation rooms, etc.

On the ground floor, to the right and left of the orchestra, two doors give access to the aviaries. Here are found collections of all sorts of birds, from the cormorant, crane and ibis to the perroquets, island birds and domestic fowl. Some of these birds, through a special arrangement, can obtain access to the open air.

A central hall of large size is devoted especially to the parrot tribe.

In the aviary hall, situated on the side toward the garden, there are two large stairways that give access to the aquarium established in the basement. This aquarium consists of twenty tanks of large dimensions, capable of being supplied with either fresh or salt water, contained in two great subterranean reservoirs provided with natural filters. These waters are put in circulation by means of suction and force pumps of a special system actuated by gas motors.—Le Genie Civil.

[Continued from SUPPLEMENT, No. 982, page 15697.]

THEATER FIRE CATASTROPHES AND THEIR PREVENTION.

By WM. PAUL GERHARD, C.E.

II.

WE have now gained a sufficiently clear understanding of the causes of fires and panics in theaters to enable us to turn to the second part of our subject, viz.: The prevention of theater fire catastrophes.

The principal measures for the prevention of theater fire disasters should have in view, first, the safety of the people in the theater, whether spectators, actors, stage hands or firemen on duty, and next, the safety of the building. The safety of the people comes first in the order of importance. The building may even burn down, but the public must under all circumstances have facilities for saving themselves. All efforts must be directed toward making the play-goers, the players and the theater employes safe. All manner of danger arising from a fire or from a panic, caused by a real or false fire alarm, should be averted, and appliances for saving life should be kept within reach. Next, the building should be made structurally safe, and efficient means for fire extinguishment should be provided, thus preventing the immense fire loss usually caused by a theater conflagration.

The safety measures, to be briefly considered hereafter, may be divided into four principal groups, viz.:

a. Measures to prevent outbreaks of fire, which include rules of theater management, regular systems of inspection; considerations of plan, size, location and construction of a theater, height of building and number of galleries, and structural details.

b. Measures to localize fires and to prevent their spreading, if in spite of precautions they do break out. Under this heading would come the fire walls, the fire doors, the fire curtain, the floor and roof construction, and the division of the theater, horizontally and vertically, into many separate fire risks.

c. Measures to insure the safety of the spectators and of the stage people, to prevent injuries resulting from a jam or crush and a panic, the suffocation by smoke and death by fire. This group includes ample means for safe, easy and quick exit from the burning building and relates to such subjects as seats, aisles, passages, doors, stairs and exits. It also embraces the questions of lighting and of ventilation, provision of stage ventilators, and special safety appliances, such as thermostats, automatic fire alarms, etc., telegraphic communication with the fire department, etc.

d. Measures to put out fires, which include all fire appliances, the stage sprinkler system, etc., a good, plentiful water service, etc.

The whole subject is discussed more systematically and at a greater length in my paper "The Essential Conditions of Safety in Theaters, an Essay on Modern Theater Planning, Construction, Equipment and Management," published in the American Architect for June and July, 1894, to which I refer those in search of details. It will suffice here to enumerate only the principal measures of safety.

1. To begin with, the theater building should be isolated as far as practicable. Then, there should be in every theater plenty of wide, well arranged and well distributed exits, leading the audience as quickly as possible to outdoors, and thereby decentralizing the crowd. There should be separate and numerous fireproof stairs, at least two for each tier. For the stage and its accessory departments provision should be made for at least two independent exits. Fireproof stairs for the workmen should lead from the rigging loft down to the stage floor. The fire at the Opera Comique taught a good lesson in pointing out the necessity of having proper means of escape for the performers and workmen on the stage, which sometimes number as many as three or four hundred people. Where the theater is not standing free on all sides, there should be wide courts on both sides and additional safety exits from the auditorium to the same, including suitable fire escapes from the balcony and upper galleries. Much the best plan, where the dimensions of the lot permit, is to have wide fireproof terraces, foyers or colonnades adjoining the corridors in each tier, which form places of safety for the audience in case they have to leave the theater suddenly. All halls, corridors, passages, stairs, exit doors, courts and exits should be free from all obstructions. All exit doors should open outward. Exits should not be reduced at any point, but if possible, should widen outward. There should be plenty of wide aisles, without steps, and no chairs or camp stools should be permitted in the aisles. It is particularly important that there should be a sufficient number of stairs and plenty of exits for the occupants of the galleries, who, as the fire catastrophes described amply prove, are more endangered than the other spectators. Those who pay twenty-five cents admission fee have surely the same rights to safety as the occupants of three or five dollar seats, and in a place of amusement, to quote the words of the Rev. Dr. Duryea, spoken at the funeral services for the victims of the Brooklyn Theater fire, "the poor should be made as safe as the rich."

Stairs from different tiers should not communicate together, nor should streams of people cross each other on their way out. All stairs should be provided with handrails on both sides; winding stairs and single steps should be avoided.

The provision of proper exits (including in the broader sense of the word aisles, corridors, stairs, doors) is by far the most important safety measure, both for fire and for panic. In fact, if properly carried out, it will save the lives of people even where all the other precautions are neglected. The aim should be to arrange the exits so that a theater can be emptied without the slightest difficulty in from two to three minutes. Much will depend upon the available site and upon the plan of the building.

If only plenty of exits are provided, so that, under all circumstances, the whole audience, even when frightened and suddenly thrown into a state of high mental excitement, can leave the building inside of two or three minutes, the fire-resisting qualities of the building are of less consequence, as regards the safety of the persons in the theater. In fact, a theater inferior in point of construction, but having exits as above described, would be safer than one built thoroughly fireproof, but otherwise not well arranged and not provided with sufficient stairs and exits, and

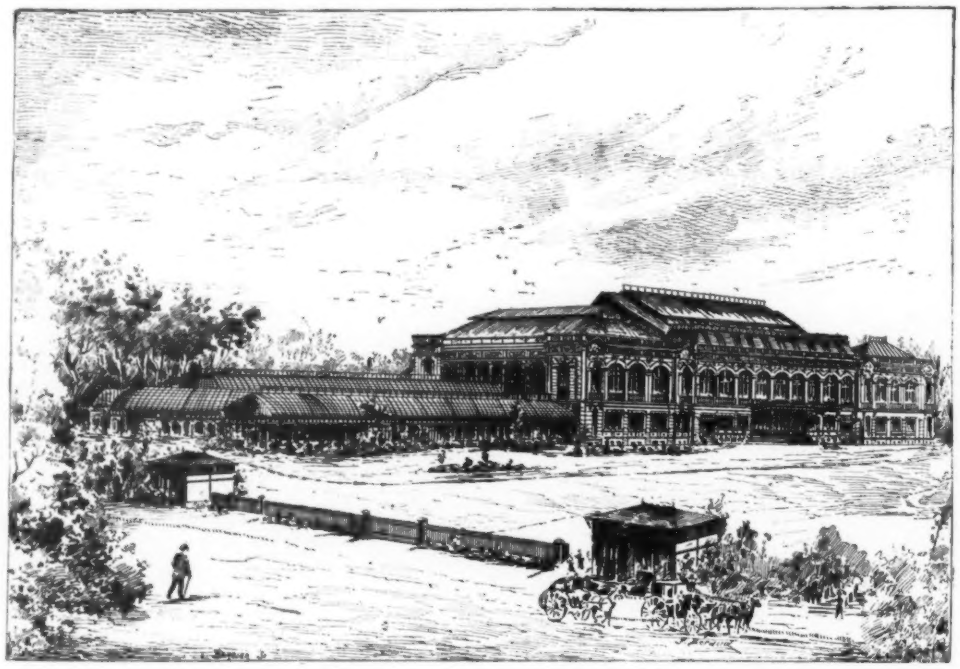


FIG. 1.—GENERAL VIEW OF THE WINTER PALACE OF THE GARDEN OF ACCLIMATION AT PARIS.

FIG. 2.—INTERIOR VIEW OF THE CONCERT HALL.

where, therefore, in case of a false or real alarm of fire, or a panic from any cause, the people would be necessarily in grave peril.

2. Recognizing, from the lessons taught by past theater fire catastrophes, that the stage is the chief point of danger, it should be the aim to completely isolate this part of a theater. Fire walls should separate the stage from the auditorium on the one hand, and from the dressing rooms and theater offices on the other. The fire wall dividing the auditorium from the stage, in which is located the large proscenium opening, should have as few other openings as possible, and none at all above the level of the stage. All openings should be kept closed by fire doors. The proscenium opening should be fitted with a fire-resisting curtain, closing as nearly as possible hermetically. The chief object of the curtain is to localize a stage fire and to cut off the fire, smoke, and the view of the fire during the retreat of the audience. It thus serves to restore confidence, and will often help to avoid the usual panic and jam. The fire curtain should be able to withstand the increased air pressure due to the heat, sufficiently long to enable the audience to make its escape. Whether the curtain be of corrugated iron, or of asbestos, it is important that the apparatus for lowering the same be located on the stage, and not in the rigging loft, which place very soon becomes inaccessible when a stage fire breaks out.

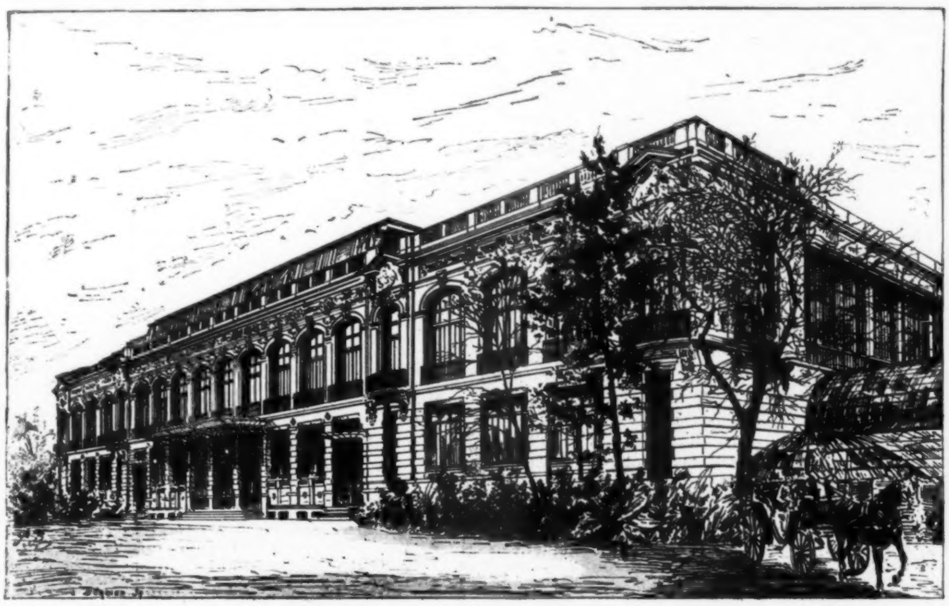


FIG. 3.—PERSPECTIVE VIEW OF THE NEW BUILDING.

3. Smoke and fire gases being the chief cause of death of the victims of theater fire calamities, it is essential that large smoke ventilators or ventilating skylights be fitted up over the stage in order to remove the smoke at the highest point of the stage roof. Incidentally, the stage ventilators tend to create a current of air from the auditorium toward the stage, and thereby prevent smoke, flames, and suffocating gases from escaping into the auditorium. In this connection the abolishment of the usual central chandelier and ceiling vent in the auditorium is important. All ventilating registers for the auditorium should have dampers which are controlled and can be closed from the stage. This measure will tend to prevent the suffocation of the people in the upper gallery in case of a fire.

4. The study of the causes of theater fires having shown that open gaslights in the vicinity of stage scenery and settings are the most prolific cause of fire, it is obvious that the stage and the scenery can be made much safer by fitting the same with incandescent electric light. All open lights, and gas lights in particular, as well as all sources of heat, should be eliminated from the stage. Incandescent electric light constitutes a brilliant, uniform, and easily regulated light. It has not only the advantage of being much safer as regards danger from fire, but it is superior also because it does not vitiate the air, because it creates much less heat than gas, and because it does away with the dangerous lighting up of gas flames, which has been the cause of many a fire. In short, the electric light in theaters has all the advantages of gas without any of its inconveniences and dangers. But, if gas lighting must be used, the gas piping should be most carefully done, all open flames should be well protected, the gas meters set in a safe place, and the best available electric spark or flash-lighting system should be installed for lighting up. In addition to the regular system of lighting, whether by gas or electricity, there should be provided in the corridors, stairs, and exits auxiliary lights, either candle lanterns or oil lamps burning vegetable oil, to make the retreat of the people safer in case the gas is turned off or in case the electric light fails. The central gas chandelier in the auditorium, moreover, should be abolished.

5. To increase the safety of the stage still further, it is imperative to insist upon the fireproof treatment of all stage woodwork by the application of fireproof paint, and likewise upon the chemical impregnation of all gauze scenery, draperies, furniture and costumes, to render same uninflammable. A further step forward in the right direction consists in the employment of light sheet iron frames or of wire cloth netting, or in the use of asbestos for scenic decorations. Improvements in the stage machinery, such as the use of hydraulic power for raising and lowering traps and scenery in place of wooden hoisting drums and hand labor, the substitution of steel wire ropes in place of hemp cord, the entire abolishment of borders and wings, are much to be desired, all of which tend to make the stage safer. These are not merely theoretical suggestions. They have, on the contrary, proved eminently practical in actual use. The improvements recommended are largely due to the Asphaleia Society, of Vienna, Austria, whose system of stage construction and stage machinery has been successfully used at the theaters of Buda-Pesth in Austrian Hungary, at the People's Theater in Vienna, at the Halle Stadttheatre in Germany, in the Victoria Theater in Sydney, Australia, and in our country in the new Auditorium Theater in Chicago.

The accumulation of much scenery or scenic decorations on or near the stage should be avoided, and not more scenery should be hung than is needed for two performances. Neither the auditorium loft nor the cellar under the auditorium should be used for the storage of scenery. Want of order on the stage is sometimes due to lack of storeroom or to an insufficient number of stage hands.

6. In the construction of the theater building fire-resisting materials should be preferred, and unprotected ironwork, granite and limestone should be avoided. The building should be divided into a large number of separate fire risks, both horizontally and vertically. The stage should be completely isolated by fire walls carried above the roof; all dressing rooms should be made fireproof and the whole auditorium and each of its tiers, corridors and stairs should be constructed in a fire-resisting manner.

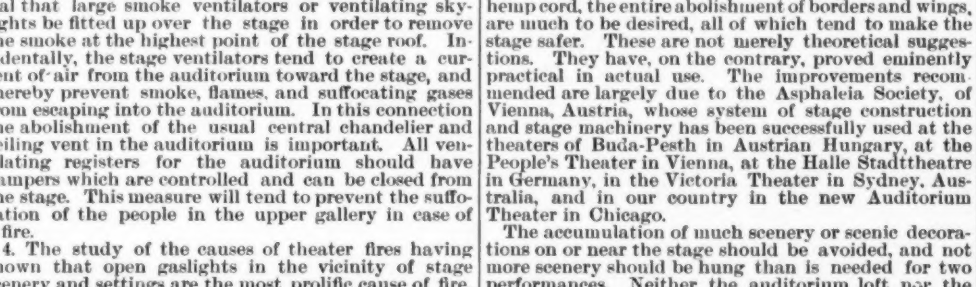


FIG. 4.—INTERIOR VIEW OF THE CONSERVATORY.

7. All scene docks, workshops, carpenter and paint shops should be banished from the theater building and placed in a separate fireproof annex. The heating apparatus, the dynamos of the electric light plant, the fire pump and the gas meter should be located in fireproof vaults, preferably under the sidewalk, but not under the stage nor under the auditorium. No living or sleeping apartments, no stores, should be located in the theater building, and no dangerous trades should be carried on in the same.

8. In order to put out a fire in a theater before it can gain headway, there should be provided an abundant supply of water under fire pressure and plenty of efficient fire-extinguishing appliances, such as one or more fire pumps, fire stand pipes, fire valves, hydrants, monitor nozzles and fire hose; a large number of fire pails, casks of water, chemical fire extinguishers, fire axes, fire hooks on poles, wet sheets, wet sponges on long poles, etc. The whole stage should, moreover, be protected by an automatic sprinkler system, supplied from a large fire tank on the highest roof, and having also an outside fire department connection, to which the fire engines may be coupled. All the appliances mentioned are useful chiefly during the first moments of a fire, and wherever provided and kept in good order and in readiness for instant use, they have served to put out many a stage fire which, without them, might have resulted in a serious calamity. It is true, however, that as soon as the flames have spread, in the majority of theaters as constructed until recently, the fire appliances would soon become powerless to subdue a fire.*

9. Much care should be bestowed upon the heating apparatus for a theater, for in not a few instances it has been the cause of a fire. A number of fires as sources of heat being out of the question on account of difficulties in attending to them, and also because they increase the fire danger, the choice lies between a warm air furnace, a steam and a hot water boiler. Furnaces can only be used for theaters of small size, and in the majority of cases heating is done by steam. The usual precautions should be observed, and the steam boiler placed in a fireproof vault, preferably outside of the theater proper. It may with advantage be combined with the electric light plant.

10. Efficient lightning rod protection adds to the safety of a theater building, and in European theaters its installation is generally included in the equipment of the building.

11. It is quite important to have on hand in every theater, for cases of emergency, a few life-saving appliances, such as rope escapes, a jumping net and a cloth chute to aid in saving persons in case their retreat from the upper floors should be too suddenly cut off by fire or smoke.

12. Finally, it will be a great help in preventing theater fires, if a fire watch is kept in the building day and night, reinforced during the hours of the performance by detachments from the city fire department. Nothing will increase more the security of a theater than frequent inspections, about which I shall say something hereafter. There should be a telegraph connection with the nearest fire department station, and automatic fire alarms at many points in the building, which should be frequently tested to make sure that they are in good working order. There should also be speaking tubes, electric bells and telegraph alarms, to bring all parts of the building into communication with each other. And lastly, the theater employes should undergo regular fire drills, so that in case of an emergency each employe will know what duty he has to perform.

13. Many of the safety appliances spoken of can be arranged so as to work automatically. Such automatic appliances are good in their way, and some of them have proved in actual experience to be quite efficient. They should not, however, be solely relied upon, and in general it will be better not to trust to automatic appliances altogether. The automatic fire alarm system and the automatic sprinkler system may be approved, but the automatic sliding skylights, or the smoke ventilators over the stage roof and the automatic fire curtain may fail to work properly just when needed. I am quite aware of the fact that others argue in favor of automatic appliances, claiming that one cannot rely in moments of danger upon the coolheadedness of men, and that in a panic every one will think of his own safety first, and theater employes will forget their duties.

But in my judgment it is infinitely better to put all such appliances in charge of a special, reliable "safety officer," who may be a trusted fireman, whose sole duty, in case of an outbreak of fire, should be to lower the fire curtain, to open the stage ventilators, to close the auditorium ventilating registers, to send the alarm to the theater engineer who runs the fire pump, and to the nearest fire engine station, to notify the audience promptly that they must disperse quietly, to see that the gas is not shut off and that the auxiliary lights are kept burning, to see that all doors leading to the stage are kept closed to prevent a draught, and who should order the water turned on at the fire hydrants, the monitor nozzles and the perforated pipe system, where such is installed in place of automatic sprinklers.

I have not, so far, made any distinction between old and new theater buildings, for the requirements for safety really apply to both alike, but, of course, are much more difficult to enforce in the case of the older structures. These are everywhere, as a rule, lamentably deficient and unsafe, and much good would result if they were frequently inspected by the fire department, and if alterations were ordered made to increase the safety of audiences. The public generally is not able to, and does not, discriminate between safe and dangerous theaters. If the older theaters cannot be made safe, particularly as regards the exits, they should be closed up by the authorities. All theater regulations should be compulsory, and the building,

* Regarding the details of "The Water Service and Fire Protection of Theaters," I refer to my paper under this title read at the June, 1894, meeting of the New England Water Works Association.

fire and police departments should have power to stringently enforce them. The law should clearly define the responsibility of architects and builders and of the theater managers, in the matter of theater safety. It is but reasonable to require of theater managers that every known approved measure, tending to increase the safety of the public, be provided for. It is likewise justifiable to require builders to construct places for public amusement in such a secure manner that all damages to life and limb are averted.

THEATER INSPECTIONS.

In the case of new theater buildings, it does not suffice to have them well planned and well constructed. There should be, after the opening, regular inspections to make sure that the laws are not violated after the new building has passed the final examination of the authorities. If subsequent alterations are contemplated, they should likewise be made to conform to the building laws. The theater license should be subject to revocation at any time for violation of the law. In the efficient periodical inspection and control of theaters by the authorities lies the greatest safeguard against fire catastrophes. Such inspections should be made much oftener than once a year. In Vienna they occur four times a year, in Paris inspections are made every month by a committee of safety, consisting of a police commissioner, an official from the city fire department, and an architect. In London monthly inspections are required. These inspections should be made not only in daytime, but likewise in the evenings during a performance, and all details should be included in the examination. Special expert surveys and tests of the gas pipes, electric conduits, fire alarms and the fire appliances should be made from time to time, and official reports made as to the results found. It is best to make inspections without any previous announcement. The results should be published, without fear or favor, in the daily newspapers. Nowhere are theater inspections carried out with greater strictness than in Berlin. All theaters are regularly inspected and surveyed, at odd times, by a committee from the fire brigade and the building department. Every two weeks the district fire marshal examines the theaters, during the day and also at night. Finally, officers of the fire brigade make nightly inspections during the performances, and a watch of trained firemen is placed in every theater during the performances. All these precautions have a tendency to awaken public confidence, and in case of a fire a panic is not so apt to occur. Indeed, there are several instances of well-built and well managed theaters on record, where during a performance fire broke out which ultimately destroyed the building, but where the whole audience left the theater quietly and in good order, and where no accident of any kind occurred.

For the safety of theaters it is essential that they be continuously watched. In the words of Mr. Garnier, the architect of the Paris Opera House, "The strict, minute and incessant watch and inspection of all parts of a theater constitute the chief defense of theaters against fires."

A century ago it was decided in France that firemen were the proper persons to do this. At first they were present on the stage merely during performances, subsequently it was decreed that firemen should be on watch in a theater during the day and the night. If the employment of fire watches is left to the discretion of theater managers, persons are sometimes engaged for this duty who are incompetent, or if competent, they are required to perform other duties besides, and being thus overworked, fail to efficiently accomplish the object sought for. Fire watchmen should be well acquainted with the building, the whole theater staff should be under their control and they should be vested with authority to interfere in case of violation of the theater regulations. In the large Paris Opera House there are always 25 firemen on duty and during performances their number is doubled. In the Vienna Opera House there are 10 men on duty. In the Berlin theaters strong fire watches, composed of the most experienced men of the fire brigade, are stationed in the building during performances, and a special police patrol is stationed in front of the house to keep the crowd in order, and to see that the exits are kept open and unobstructed. During all performances a detachment of firemen should be stationed on the stage, and should watch not only the lighting arrangements, the fireworks, the firing of firearms, but also have charge of the fire-extinguishing and life-saving appliances, and see that they are kept in order and ready for use. At the close of each performance, an inspection of the whole theater should be made by the fire watch, attention being paid in particular to the heating and lighting apparatus, to the decorations and scenery, and to the dressing rooms.

THEATER MANAGEMENT.

Strict rules and regulations pertaining to the management of theaters should be drawn up by the authorities, and enforced by the fire, building and police departments, which, as regards theaters, are correlated. Such rules of management relate to the proper storage of decorations, scenery, furniture and property, to the maintenance of general order, cleanliness and discipline; to the removal of rubbish, litter and ashes, to keeping the scenic decorations free from dust, keeping all corridors and exits unobstructed, and likewise to holding all fire stand pipes, hydrants, fire pails and casks of water accessible and ready for use.

They also relate to the use of open fires and lights, the employment of special lights and fire effects, the use of fireworks, of firearms, the representation of actual fire scenes, the use of matches, the prohibition of smoking or lighting cigars in the auditorium, foyers or dressing rooms, and should only permit the same where needed in the course of the play. These rules should also include the daily use of the fire curtain, and the opening of all exits, the maintenance of auxiliary lights, either oil lamps or candle lanterns, in corridors, courts and exits, the keeping up of steam under proper pressure at the fire pump during performances, the employment of a special fire watch and a theater night watch, etc. They should require the fireproof treatment of all gauze costumes, and prohibit the use of open lights in the wardrobes and dressing rooms. A penalty should be enforced for the use of fire pails for other than fire purposes. Moreover, the number of persons in each tier should be limited by law, and standing room in the aisles should be prohibited, and a heavy fine enforced for any violation of these rules. The practice of a sudden, unannounced darkening of the auditorium should not be permitted, nor any dangerous fire exhibitions on the stage, except where the stage is absolutely fireproof. Special precautions should be enforced where the stage is decorated with natural branches of fir trees, which when exposed to heat dry out quickly and become extremely fire-hazardous, and also where the auditorium and the stage are temporarily thrown together, as during masquerade balls. The rules should prohibit workshops of any kind in the theater proper. They should finally require clear plans of the theater, showing the exits, to be hung up at conspicuous points and also to be legibly printed on all theater programmes, and last, they should compel the plain marking of all exits in large letters painted over the doors.

One cannot learn the dangers incident to large fires, nor the effect of good fire-extinguishing appliances, better than by being daily engaged in fighting flames, nor can anybody have a better appreciation of the effect of suffocating smoke than a fireman. Firemen, therefore, are as well qualified as builders, architects and engineers, to judge of the security of a theater building, and of the efficiency of the safety measures adopted. The training of firemen is such as to make them proper persons to examine and pass upon the plans for new theaters, and to inspect both the theaters in course of erection as well as those already built. With their assistance the rules and regulations for theater management should be framed, they should be entrusted with the inspection of theaters, to see that the rules are enforced; finally, they should be in charge of the fire appliances in theaters, and should direct the fire drill of the employes.

Only a few more words in conclusion. Experience teaches that after each theater fire, accompanied by loss of life, the greatest excitement prevails for a time; the daily papers, the magazines and the technical press are full of articles, discussing defects of theaters and suggesting remedies; the public refrains temporarily from going to these places of amusement; the authorities show the greatest zeal in making official inspections; and theater managers actively undertake interior improvements. Very soon, however, the excitement subsides after a little while the lessons of the calamity are forgotten, the theater management resumes old habits, the most common precautions are neglected, the public becomes again indifferent to the dangers constantly threatening them in unsafe theaters and everything goes along as before. This, I need hardly say, is all wrong.

There is an old adage which says, "In time of peace prepare for war." Applied to our subject, it means that the movement for theater reforms should constantly be kept stirred up, that, without unnecessarily alarming the public, interest in the subject of theater fire prevention should be ever maintained, and that quiet but persistently radical measures should be adopted to stamp out the grave dangers to which human life is exposed in the theaters of many of our cities.

Strict theater building laws and frequent theater inspections by the fire departments constitute the most important factors in lessening, for the future, the number of theater fire catastrophes.

AIDS TO ASEPTIC SURGERY.*

By EDMUND WHITE, B.Sc. Lond., F.I.C., Pharmaceutist to St. Thomas' Hospital.

STERILIZED SURGICAL DRESSINGS.

THE supply of sterilized dressings to a large institution presents a number of difficulties which are not encountered in private surgical practice. I propose to give an account of the apparatus and method of procedure which have been adopted in St. Thomas' Hospital.

The sterilizer, Fig. 1, is a cast iron circular vessel, having an internal diameter of two feet four inches

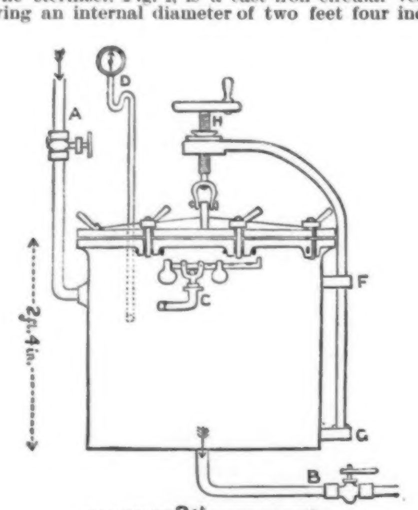


FIG. 1.—APPARATUS FOR RENDERING SURGICAL DRESSINGS ASEPTIC.

and a depth of two feet. The walls are ¾ inch thick, and are covered to a thickness of two inches with asbestos to prevent loss of heat as much as possible. The lid is flat, ¾ inch thick and strengthened by four radial ribs. It is secured in place by six swivel bolts, four of which are shown in the figure, and raised by a wheel and screw, H, passing through an arm or davit. This davit turns in the two sockets, F G, thus allowing the lid to be swung aside when raised. Inside there are two removable shelves of perforated galvanized iron, supported by projections cast on the interior of the sterilizer. The steam supplied from the boiler of the pharmaceutical laboratory enters at the side through the pipe, A, waste steam and condensed water escape through the pipe, B. A safety valve, C, and pressure gauge, D, complete the apparatus.

The dressings are cut, folded, or made into the form in which they will be used, and placed into cylindrical glass jars provided with flat overlapping lids. The size mostly used is eight inches in height and four inches in diameter.

The jars are filled by the "sister," who has charge of the case for which the dressings are intended. They are placed in the sterilizer lying on their sides with the lids off, and exposed to the action of steam for

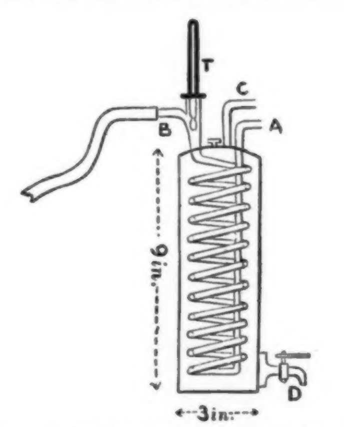


FIG. 2.—TEMPERATURE REGULATOR FOR USE IN STERILIZING WATER.

one hour. The steam pressure is allowed to rise gradually during the first fifteen minutes until the gauge shows 18–20 lb. to the square inch, a pressure corresponding to a temperature of about 125° C. At the expiration of the hour the supply of steam is shut off and the compressed steam allowed to escape by opening the tap in the pipe, B. The lid is released by unscrewing the swivel bolts, and raised about half an inch to allow the remaining steam to diffuse out. It is next swung aside and the jars removed by an attendant, who spreads over the mouth of each a layer of sterilized cotton wool before putting on the lids. The layers of wool being compressed between the edge of the jar and the lid prevents the ingress of dust or germs. Over each jar a long, narrow label, gummed at the ends, is placed, on which is marked the ward from which the jar is sent and the date of sterilization. The jar cannot be opened without breaking this label, which thus indicates whether the contents have been tampered with after sterilization.

It was found at first that the materials came out too damp, sometimes even quite wet, thus diminishing their absorbent power. This defect is now remedied by first heating the empty sterilizer by the passage of steam for about fifteen minutes. It is then opened, and after allowing the inclosed steam to escape, the jars are put into position. The sterilizer, being of massive construction, retains the heat imparted to it by the preliminary steaming, and after waiting fifteen minutes for the jars and their contents to become heated, the steam is again turned on, and sterilization completed in the manner already described. After this preliminary heating in the hot dry sterilizer there is much less condensation of moisture in the dressings. For the first five minutes of sterilization steam is allowed to pass freely through the apparatus, so as to displace the air and secure a thor-

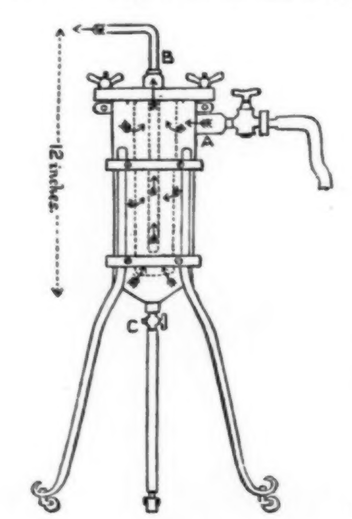


FIG. 3.—KIESELGUHR FILTER ARRANGED FOR STERILIZING WATER.

oughly moist atmosphere, and for the rest of the time the tap in the pipe, B, is kept slightly open, just enough to allow the condensed water to escape with a little steam.

STERILIZED WATER.

The apparatus for the supply of sterilized water for irrigation, etc., in surgical operations, consists of two parts, the first, Fig. 2, in which water supplied from the main is brought to the required temperature; the

* St. Thomas' Hospital Reports.

second, Fig. 3, in which the water is sterilized by passage through a Berkefeld (kieselguhr) filter.

Fig. 2 consists of an outer copper cylinder, nine inches long and three inches in diameter, in which is placed a coil of copper tubing thickly tinned inside. Through this coil water passes from the hot water main, and its temperature is recorded by the thermometer, T. As this is nearly always hotter than required, the space around the coil is filled with cold water entering through the tube, C. By means of the tap, D, at the bottom the outflow of this cold water may be so regulated as to bring the water leaving the coil to the desired temperature. The water then passes to the filter through rubber tubing sufficiently long to allow the filter to be moved easily to any part of the operating room.

The filter, Fig. 3, which is twelve inches long by about three inches in diameter (outside measurement), consists of a cylinder of compressed kieselguhr inclosed in an iron jacket. In the figure the position of the filtering cylinder is indicated by the dotted lines. The water entering at A fills the space between the jacket and the cylinder; it is driven through the latter and escapes sterilized by the tube, B. The filter is mounted on an iron tripod, provided with rubber-tired wheels to enable it to be easily moved about the operating table. With twelve feet of tubing between the coil and filter it is found that the temperature of the water passing from the thermometer, T, Fig. 2, to the orifice of B, Fig. 3, falls from 2° to 5° Fah., according to the rate of flow. That is, if water at 100° Fah. be required, the thermometer should indicate 102°–105° Fah.

When hot water is not available the coil may be used thus: Cold water is passed through the coil, the space outside being also filled with cold water. A gas burner placed beneath the cylinder heats the water around the coil, the water passing through being brought to the desired temperature either by regulating the gas burner or by opening the tap, D.

In places where the pressure in the hot and cold water pipes is the same, the waters may be mixed, before entering the coil, in the proportion to give the desired temperature. Regulation of temperature by the flow of cold water through C to D, Fig. 2, is then unnecessary. It is advisable even in this case to have the coil arranged as shown, for in case of failure of the hot water supply, gas may be used as the source of heat.

The sterilizing power of the filter has been tested at the end of one hour's, twenty-four hours' and forty-eight hours' continuous passage of water. In no case could any growth be obtained by inoculating culture tubes, either at ordinary temperature or at 40° C.

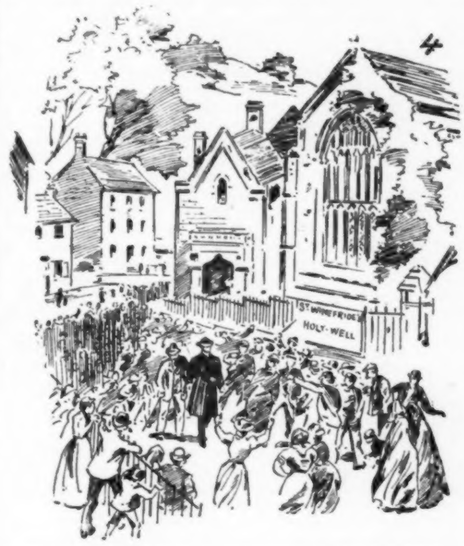
It is advisable to remove the kieselguhr block, boil it in water about every other day, and lightly brush it in order to remove the deposit which collects on the outside and retards the flow of water through the filter.

WELSH MIRACLES.

OUR readers are familiar with the famous grotto of Lourdes in France, where thousands of devout pilgrims of the Catholic church resort for worship and the cure of ills that flesh is heir to. Miraculous interposition is attested by thousands upon thousands of the devout visitors to Lourdes. And now a new shrine has been developed in Wales at the church of St. Winefride, Holywell.

The town lies on the London and Northwestern line from Chester to Holyhead, and is thus easily reached from all parts of the United Kingdom. Pilgrims come from north and south, east and west, and the accents of Scotland and Lancashire and the Midlands can all be heard in the hospice and the bathing place. The hospice is a conveniently arranged building for the temporary housing of pilgrims. The men have the ground floor, the women the first floor. There are several large dormitories tightly packed with beds, and a dining hall with a statue of the saint. For board and lodging a charge of one shilling a day is made.

The building which covers St. Winefride's Well at Holywell is a remarkable and beautiful architectural work. It would appear to date from about the close of the fifteenth century, and is in what is called the perpendicular style. The exterior, which faces the basin or bath, presents a well designed facade, pierced by three lofty four-centered arches, the center of which



ST. WINEFRIDE'S SHRINE, HOLYWELL.

is open down to within three or four feet of the water, but the side ones are blocked to half their height with stone screens, which are pierced by Tudor doorways giving entrance to the hall which contains the well or spring itself. This is inclosed by a most exquisite little edifice planned in the form of a star, with a very graceful vaulting overhead, which, in design, bears an extraordinary resemblance to a fountain which seems to be spurting out of a crown of flowers, from the center of which hangs down a pendant, formerly adorned with delicate sculpture, but now too much mutilated to be quite intelligible. In all probability it represented the martyrdom of St. Winefride, and if so the whole conception of the work was singularly poetical and beautiful, as the spring is said to have flowed forth from the spot where she was beheaded.

The sides of this exquisite little structure have been evidently inclosed by screenwork of delicate tracery, the greater part of which has unfortunately disappeared. However, it is lovely in its decay, and is even now one of the most poetical examples of Gothic architecture to be met with.

At this church is preserved as a sacred relic one of the alleged fingers of the saint, and to it are attributed miraculous influences. The pilgrims bathe or wash in the sacred pools pertaining to the church, and the priest touches them with the precious relic or finger. Many wonderful cures are recorded, and there are stacks of old crutches left by the halt that witness to the truth of the results. The London Daily Graphic in a recent issue gives sketches and particulars from which we derive our illustrations and the information here given.

Mr. H. W. Brewer, writing to the Graphic, says: The extraordinary love and reverence which people had for wells and springs in the middle ages is evinced by the number of churches and even cathedrals built over them. The cathedral of Paderborn, in Westphalia, is erected over the source of the River Pader, which flows out in seven little streams beneath the building. A sort of shrine—very much plainer, however, than that at Holywell—is built over the spring in the transept of the church, and looking down into this one sees the water bubbling up out of the ground. In the cathedral of Ratisbon is a large well covered with a very elaborate Gothic canopy and adorned with statues of our Lord and the Woman of Samaria. In the cathedral of Augsburg there is a very lively spring which rushes and splashes into a great basin; and in the cathedral of Freiburg is a spring with a fountain attached to it. The latter, however, is only allowed to play once a year, because people complained about the spray from it wetting them through when they were saying their prayers. The church of Folgoet, in Brittany (literally the Fool's Well), is built over a spring. In the cathedral of Prague, in Bohemia, is also a well, the cover of which is a fine work of art by the eminent sculptor Peter Fisher. In Ireland the holy wells attached to churches are too numerous to mention, and Lord Dufferin, in his Letters from High Latitudes, mentions that he found the remains of hot wells amid the ruins of the churches and monasteries in Greenland.

MASTERING A BICYCLE.

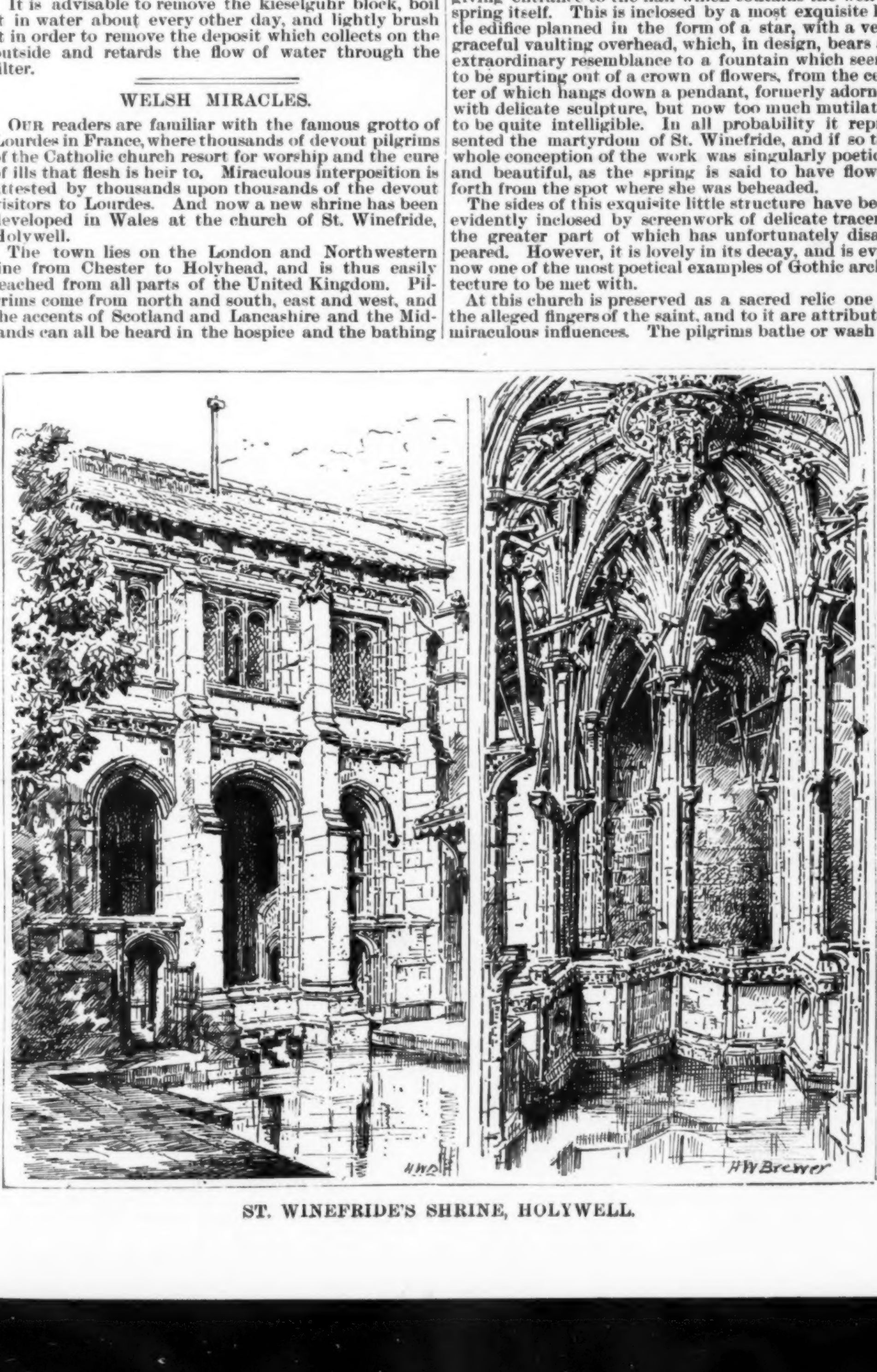
PERSONS who have achieved the feat of learning to ride the bicycle are wont to aver that it is easy, but those whose struggles with that metallic mustang belong to the active present are not likely to subscribe with any heartiness to the affirmation. It is not to be denied that there are persons who ride with considerable ease and supposed safety, even upon a second attempt; but there are also abnormal beings who can tell you the cube root of any sum without figuring, or from actual memory match together days of the week and dates of the month years back. Such exceptions prove nothing, any more than a single swallow makes a summer. It is quite true that with perseverance in effort anybody can learn to ride one of these machines, but to say that everybody may do so easily is quite another story, and one that truth would never peep out of her well to smile upon. Luckily, the end to be attained is well worth even extraordinary endeavor. That such ease and swiftness of locomotion afford much pleasure to riders is apparent to one who simply stands by the road and sees them go by, but it cannot be adequately appreciated until actually experienced, and he must be a poor philosopher who cannot make up his mind to a few mishaps and discomforts when they are the necessary introduction to the realization of such enjoyment.

There are two ways of learning to ride a bicycle. In one you acquire possession of a bicycle—with or without the owner's consent—and, as far as possible from the madding crowd, engage in single combat with it. This is rarely done except by the sort of person who thinks the best way for teaching a boy to swim is to throw him into deep water and leave him to take care of himself.

A football player's suit, with the addition of a baseball catcher's mask, would be a good costume in which to learn bicycling alone. It would be something of a shield, at least until the machine had discovered the unprotected spots and concentrated its attention upon getting at them. Of course, a person who has never had any experience in the premises will be likely to doubt that a machine makes discoveries and has any intention to concentrate upon malicious mischief, but that would simply be from lack of appreciation of how much this machine is unlike any other. Ask the man who knows, the contused person who has just fought a lively round with his bicycle, and he will fervently assure you that the iron brute has the cunning to invent new ways for flooring him in almost endless variety, and the malice to trample upon him when he has been downed.

Its only right to be called a "safety" is in the qualification that the injuries it inflicts are not at all likely to be fatal. They may include severe bruises and sprains, perhaps even the fracture of some tender little bone, but it is hardly possible for it to break your neck, as the tall "velocipede" of old times could with hardly an effort. The full range of its possibilities as a doer of harms you are pretty certain to know well, if you undertake to master it alone. Those who have done so are not without justification for the insolent pride with which they are wont to dilate upon the achievement, but there does not seem to be any ground for the claim they often advance that such rugged experiences make any better riders ultimately than gentler methods, in which the inherent viciousness of the wheel is curbed and restrained from the start.

The other method of learning is by the direction and assistance of a practical bicyclist. If the person giving such aid is simply a friend, who with abundant good intentions combines lack of experience as a teacher, the results are likely to be almost as discomposing as if you tackled the job alone. He gets you on the saddle, gives ample advice, and a shove—and while rescuing you from the angry machine and helping you to your feet a few seconds later, asks that exasperating question, "Why did you not do as I told you?" You had no time to think of his instructions; none of them, you suspect, would have suited that particular emergency anyway; even now you don't clearly understand how the thing got you down and so cannot think what you should have done. "Why, it's the easiest thing in the world. Look here!" he says, and lightly swinging himself into the saddle, goes sailing off down the street, wheels, comes back, and circles around you, with such ostentatious superiority in his accomplishment that you yearn to throw a brick at him. Then you get aboard again and have another



ST. WINEFRIDE'S SHRINE, HOLYWELL.

experience of trouble in some new way. The best that can be said for this mode of learning to ride the bicycle is that it tends to promote the gayety of surrounding neighborhoods.

The sensible thing to do when you have made up your mind to master the wheel is to go to a school where experienced and careful teachers are provided, and engage a course of lessons. Fifty cents are charged for a single lesson or two dollars for five, half an hour being the duration of each. The price would be none too high if the greater part of it went to the teachers, for more severe and continuous labor than theirs during longer hours is performed by nobody. From ten o'clock in the forenoon—and in some places even from eight o'clock—until ten o'clock in the evening, with only short intermissions for meals, they are constantly on their feet, walking, trotting, running, and at the same time, almost all the while, exerting themselves to prevent their pupils falling, maintaining unceasing vigilance over every movement, applying all their strength and dexterity to keep the wobbling combination of clumsy rider and tricky wheel from coming to grief. It is harder work than blacksmithing or letter-carrying or pugilism. And with it all, they have to be patient, polite, complaisant, to look pleasant, and not show how tired they are. It is enough to make a sympathetic man's muscles ache just to think of how weary the poor fellows must be, and if they looked as they must feel toward the close of the day, nobody but women would take lessons then.

The first thing a good teacher does, when you present yourself for your first lesson, is to put on you a strong leather belt, with an adjustable hand loop, which he establishes in place on the left side of the back. Then he helps you to mount. It doesn't matter much at this stage of the game, if you are a man, how you get aboard. Correct mounting is the special field of trouble that you will come to in time, after you have learned how to stay on when once you have got there. For the present, you climb up; or, if your legs are long enough, you lay one over the saddle and hoist yourself, or you get a sort of stirrup purchase somewhere and mount the wheel as you would a horse. Of course, the teacher holds the machine, which seems frantically eager to lie down, on one side or the other, or to double itself up as if it were all loose joints.

A lady begins her practice by learning to mount. Her attire makes this necessary, especially if she wears skirts, and if she has a tilting saddle it is not at all difficult. With an ordinary saddle, however, it is not easy to get her skirts so hitched up that they will be properly in place when she mounts, to give the wheel such impetus that it will keep up, to rise at exactly the right instant and keep her foot on the further pedal. Yet all this complicated, combined movement she must become expert in, and it is rather surprising to see how soon she generally does so. Teachers affirm that, as a rule, women learn to ride well more quickly than men.

"Keep the pedals moving" is one of the earliest and oftenest injunctions you will hear from the teacher. You realize in the first three minutes that momentum is essential to keeping your balance. The turning of the pedals is very easy, and you really mean to keep them going steadily, yet unconsciously you stop the motion again and again. The trouble is that the machine is willfully doing a series of mischievous things to distract your attention and confuse you. Suddenly it attempts to lie down. The teacher, with his left hand on the handle bar and his right sustaining you by the belt, switches the front wheel around suddenly in the direction the attempt was made. Instantly it makes a plunge to get down in the opposite direction, and he arrests it by a reverse twitch at the bar and a prodigious heave on the belt. Of course, you forget to do anything with your feet while these animated proceedings are going on. You feel as if anything you might do would be an injurious interference. "Keep the pedals moving!" he reminds you, and you hastily obey with such vigor that the wheel fairly leaps forward. He does not check you. He may have to run, but that is not so bad as holding you up at a standstill. Presently, from no cause that you can find, the machine enters upon a succession of long, swinging yaws, first to one side, then to the other. "Turn the wheel quickly in the direction you are yawing; then recover instantly. Do not let it go too far either way," he enjoins you. It's all very well to say, "Do not let it," but it is not the sort of thing that waits for permission. But his vigilance, skill, and strength are too much for its evil intentions this time, and you soon find yourself going straight again. Once around the big hall you go very nicely, rapidly acquiring confidence and unconsciously increasing your speed. This is what the treacherous mechanical broncho has been waiting for. Suddenly one of the pedals eludes you. It is not at all an exaggeration to say that the sensation of feeling for a pedal that is not there is simply awful. You frantically paw the air for it, and it dodges you, until you think it must have dropped off, and as you bend over and look down to see if it has not, the machine makes a desperate effort to stand you on your head. At this point it is well to get off for a few moments. Justice cannot be done to the situation by any remarks a novice can make from the saddle.

Just to show you what you should do, the teacher gracefully vaults upon the saddle and darts about a few moments with the ease and almost the speed of a "devil's darning needle." When he brings the bicycle back to you it is on its good behavior, and for three or four minutes, probably, does not attempt to play you a trick. Then it begins yawing again. By this time you understand that movement as indicative of coming mischief, just as lying back the ears is the warning a vicious mustang gives that he is going to make trouble. "Do not grip the handles so rigidly; hold them lightly, with your muscles easy, ready for quick motion; go a little faster, and make short plays of the wheel each way, catching its swings, until you get it to running steadily." Excellent advice; and as long as you remember to follow it, and nothing diverts your attention, you get along very well; but presently, just when you are felicitating yourself upon getting the hang of it so quickly, the machine perversely takes a header toward the wall, you lose both pedals, and lean over in the wrong direction, and before you can say "wow" you are down. Of course, the teacher has so eased your unavoidable fall that you are not at all hurt, more than that, he wins your gratitude by a pretty little bit of acting. He assumes that something is wrong with the bicycle: the handle bar is crooked, or the saddle is too high, or too low, and pretends to fix it. You know your tumble was due to your own awkwardness; you know that he knows it, and you know he knows that you know it; and yet, I don't care how honest you think yourself, you feel better for the pretense.

After you have got so that you can go about the hall nicely in one direction, say from left to right, the teacher says, "Now we will go the other way." It is a preposterous thing that you should now find yourself almost as awkward and liable to accident as you were at the beginning, but such you find to be the case. Some little trouble at turning the corners might naturally be expected; but you know the principle involved, inclining your body toward the inside of the curve you are making, and ought to be able to accommodate yourself readily to the change. That which will surprise you will be the discovery that you cannot go so well on a straight line, when you start from right to left, as when you went from left to right. It may seem absurd until you have tried it, but is a fact nevertheless, and a good teacher will not willingly let you consider your tuition complete until you have conquered this difficulty.

And it is quite in keeping with the perverse disposition of the wheel that it should have waited until now—when you fancy yourself able to go alone, and are trusted by your teacher to do so and are consequently held responsible for what you are supposed to do—in order to involve you in a new order of troubles. It is the wheel that, with spiteful glee, darts across the hall to achieve a collision with another wheel, comes within an ace of shaving off the toes of a row of young women sitting at the edge of the floor, plunges into the rear of a gentleman just "teetering" himself for an essay at mounting, and does any number of other devilish things, but it is you who will get the blame for them all.

Finally, you feel that you can quite satisfactorily control the wheel, going either way, turning corners, dodging collisions, arresting promptly those alarming yawings and measurably at least applying your teacher's oft-repeated injunctions to "make the pressure on the pedals aid in preserving your balance"—

THE FOAM FLOWER (TIARELLA CORDIFOLIA).

words that seemed simply sarcastic when you first heard them. And now you seriously undertake to learn what you have been making tentative staggers at for some time—the art of mounting. You devote a whole lesson to it. The teacher shows you three or four ways in which he can place himself on the saddle, seemingly without an effort, but when you try them each is rather more difficult than either of the others. He tells you to lean the machine toward the right as you stand at the left, or behind it, preparatory to mounting, and you revolt against him, feeling that such an inclination will only aid in precipitating you headlong over the saddle. He lets you try it your way, and when he helps you up from the ground you feel humbled. Perhaps it is as well to draw a veil over this saddest part of learning to ride a bicycle. Patience and perseverance will conquer eventually, and at most the season of tribulation is not protracted. Most persons learn to mount, ride and dismount fairly well in the course of five lessons, and hardly anybody requires more than two courses. But to even those who find it most difficult, the first hour on the road upon the conquered bicycle is ample repayment for all that has been gone through.—N. Y. Tribune.

THE FOAM FLOWER.

IT is a strange fact that while many plants of doubtful value are widely distributed in gardens, some real treasures, for no apparent reason, are overlooked. Such has been the fate of the lovely little foam flower, and though it is a perfectly hardy plant of rapid increase, flourishing in almost any soil and position, and has been in our botanic gardens for 150 years, it is not so often seen as it might be. It is a plant of great beauty both of leaf and flower; the little starry flowers are creamy white, the buds delicately tinged with pink, a good mass of them seen a few yards off having a close likeness to a wreath of foam. The young leaves are of a tender green, daintily dotted and veined with deep red, while the older ones at the base of the plant are of a rich red bronze. Whether planted in rock garden or border, it is a beautiful and delightful plant. All the care it needs is division every two years, the plants being at their best the second year after division.—The Garden.

FLORAL NOTES FOR OCTOBER.

By CHARLES E. PARNELL.

IN all places where a general collection of plants is maintained, the month of October will find an abundance of work on hand in the greenhouse as well as in the ornamental department. In many places slight frosts and lower temperatures have given ample warning of the approach of colder weather, so the cultivator should be very careful to have all plants placed beyond the reach of danger, and all half hardy plants such as hydrangeas, pomegranates, crape myrtles, etc., should be removed to their winter quarters before they are injured by excessive cold and wet. The greenhouse or conservatory at this date should be properly arranged for the winter. If not, lose no time in placing everything in order, and in arranging the plants; carefully study their requirements as to light, air and temperature. As this is the beginning of a new season under glass, it is advisable to give as much ventilation as possible whenever the opportunity offers; yet at the same time the proper temperature must be maintained. It is well to avoid fire heat as long as possible, but in continued cool or wet weather it must be employed. Close attention must be given to watering and syringing, and it is very important that all dead and decaying flowers and foliage be promptly removed.

In the flower garden and ornamental department constant attention will now be necessary to have everything as neat and attractive as possible. The lawn should be mowed as often as necessary, and the walks cleaned and rolled. Remove all plants from the beds and borders as soon as they are much damaged by frost. Keep all beds and borders smooth and clean and their edges trimmed so that the beauty of the remaining plants may be fully enjoyed in the bright October weather.

As soon as the first frosts have given a check to vegetation the planting of ornamental trees and shrubs should be pushed forward as rapidly as possible so that the roots may get a start before the ground becomes frozen. The planting of hardy perennial plants should also be completed as early in the month as possible.

Azaleas.—Should be carefully watered, keeping them as cool as possible.

Achimenes, Gloxinias and Tuberous Begonias.—As soon as the foliage has entirely decayed let them be removed from the frames in which they were placed in September and stored in a dry situation, where an average temperature of 50° is maintained.

Bulbs.—Such as hyacinths, tulips, crocus, narcissus, snowdrops, etc., for successional winter and spring blooming may now be planted.

Bouvardias.—From now on should be given an average temperature of 55°.

Chrysanthemums.—Thin the buds of large flowering varieties. Do not crowd the plants, and give liquid manure twice a week until the buds show color.

Cestrums.—After the plants cease blooming they can be treated as advised for half hardy plants.

Cinerarias and Calceolarius.—Repot when necessary, air freely, water carefully. Keep a sharp lookout for the green fly.

Caladium.—Treat the fancy varieties as advised for achimenes. C. esculentum can be lifted several days after the leaves have been destroyed by frost, the bulbs dried and cleaned and stored for the winter in a cool cellar.

Cannas.—Several days after the foliage has been destroyed by frost, let the stalks be cut down to within a few inches of the ground, then on a dry day lift the plants and place underneath the greenhouse benches or in any situation where a temperature of from 50 to 55° is maintained during the winter months.

Dahlias.—May be treated as advised for Caladium esculentum. See that they are securely labeled. Dahlias keep well throughout the winter if placed in barrels, and treated as one would potatoes.

Fuchsias.—The summer blooming varieties may now be placed underneath the greenhouse stage or in any situation where half hardy plants are to be placed for the winter.

Freesias.—Plant at intervals of every two weeks to secure a succession of bloom.

Gladioli.—After the foliage has been destroyed by frost, lift the bulbs, dry, clean, place in paper bags, label, and store in a dry, cool place secure from frost.

Hydrangeas, Pomegranates, Crape Myrtles, and all half hardy plants should be placed in a dry, cool cellar as soon as cold weather sets in; keep them quite but not dust dry at the roots.

Hyacinths and Tulips.—For bedding purposes may now be planted. Plant also in pots to secure a succession of bloom.

Ixias, Sparaxis and Brodiœas.—For winter blooming may now be potted.

Lilies.—May be reset about the end of the month, planting from four to six inches deep according to variety. L. harrisi may yet be planted for spring blooming.

Pansies and Daisies.—Raised from seed for another season's use may now be removed to a cold frame, placing them in rows about two inches apart. Keep as cool as possible.

Plumbago capensis.—In pots or tubs may be treated as advised for hydrangeas.

Poinsettias.—Should now be given liquid manure twice a week. Also give them an average temperature of 60°.

Pæonias.—May now be divided, replanted or removed.

Perennial plants.—In beds and borders, should be securely labeled.

Roses.—Should be syringed daily in bright sunny weather, and given a night temperature of 55 or 60°.

Shrubs.—For winter blooming, such as deutzias, spireas, etc., should be lifted and placed in pots or boxes. About the end of the month they can be brought inside, and placed in a cool cellar until wanted for use.

Tigridias.—May be treated as advised for gladioli.

Tuberoses.—That are late in blooming may be lifted potted and brought inside for blooming; the remainder may be lifted, dried, cleaned and stored in a dry place where a temperature of 55° is maintained.

Violets and Pansies.—In cold frames for winter blooming, should be given all the air possible, keeping clear of weeds and decaying leaves. Vases, hanging

baskets, window boxes, etc., should now be emptied, thoroughly washed and placed under cover.

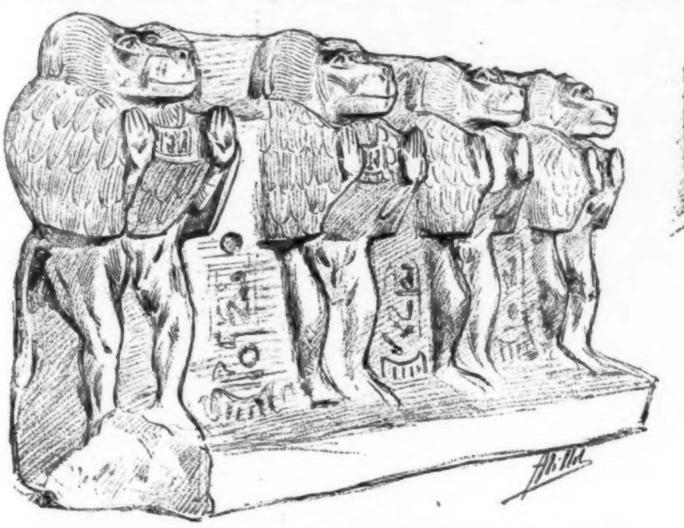
Zephyranthes.—May be treated as advised for tigridias.—Country Gentleman.

THE BABOONS OF THE JARDIN D'ACCLIMATATION.

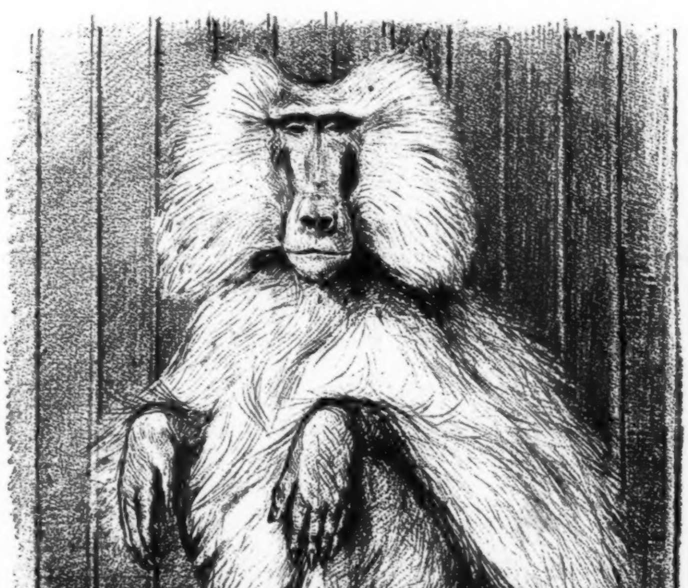
On the strength of the statements made by so-called scientific books, we might expect to find in the baboons which are kept in the Jardin d'Acclimatation horrible animals possessed of great ferocity. Is it their amazement to see so many people around their cages or is it already the effect of our civilization? The impression is favorable. The four magnificent monkeys are calm, and with their small eyes and long hair on their temples they resemble old people rendered myopic by study and plunged into profound meditation. They only emerge from their apathy to look for fleas, which is a very amusing performance to witness. From time to time they give voice to a strange, sad cry. By this trait they are somewhat allied to the dog, which they resemble by reason of their terrible canine teeth and their elongated muzzles. The carnivorous nature is revealed when they are made angry; they then resemble enraged lions and give vent to horrible cries. Baboons are natives of Africa, those in the Jardin d'Acclimatation coming from Abyssinia. Far from living in a forest, as their name (hamadryas) would seem to indicate, they live exclusively among the rocks of high mountains. They are very sociable animals and live in communities, some being supported by the others.

The males serve particularly for the defense and provisioning of the others. The females bring up the young ones with a care which is amusing. They all eat at once and then repose; in the evening they all go to a pool to drink. If a baboon finds a large stone under which he expects to find food, he goes for several of his comrades, who, by uniting their efforts, succeed in triumphing over the obstacle. Their expeditions are made in common against plantations, but they know the dangers to which they are exposed, and whenever possible they make a reconnaissance in daylight to see the actual state of things. When there is the least chance of some hidden danger, they make a sign to the others and all run away. "They form," says Brehm, "a chain extending from the orchard to a neighboring mountain. Those within the inclosure gather the fruit and pass it to the others outside, who in turn pass it from hand to hand until it has reached the mountain safely. To avoid the effects of the wrath of the proprietor they place sentinels, who, at the least noise, give vent to a sharp cry and all disperse."

In spite of their good qualities, chief among which is their extraordinary love for their little ones, they are savage and bad tempered. Their greatest fear is for leopards and serpents, of which they have great horror. To capture them two methods are employed. In a cavity of a tree some odorous fruit is placed, through the center of which a hole is pierced. The monkey passes his hand through the orifice, seizes the fruit and vainly attempts to withdraw his hand; he never thinks of giving up his prey. The other method consists in placing in their way several vases filled with spirituous liquor, of which the baboon partakes, and is quickly brought to a condition which permits of an easy capture. The baboon has played a considerable role in the sculpture of the monuments of Egypt. They are so often represented that they indicate that they were formerly the object of a veritable cult. For the foregoing particulars and for our engravings we are indebted to L'Illustration.



BASS-RELIEF IN THE EGYPTIAN MUSEUM OF THE LOUVRE, REPRESENTING BABOONS.



BABOONS AT THE JARDIN D'ACCLIMATATION, PARIS.

THE PROGRESS OF ASTRONOMICAL PHOTOGRAPHY.*

In August, 1889, Prof. Pickering pointed out that a star camera with double objective 24 in. in diameter would be a powerful aid to astronomical photography, and Miss C. W. Bruce, of New York, came forward and gave $50,000 for the purpose of making this great instrument for photographing star spectra. On January 8, 1890, Prof. Pickering announced that one of the results of the work done under the Draper Memorial was the discovery of a new class of binary stars, whose components are far too close to be seen by any other method.

It was first noticed that the conspicuous lines in the star were sometimes double, and an extended series of photographs revealed the fact that the duplication came at intervals of fifty-two days, and this is completely accounted for if one assumes the existence of two stars with similar spectra very close together and revolving round each other in a plane passing nearly through the sun; the doubling of the line is, of course, caused by the fact that the star at one time is moving toward us and at another away from us. A similar case was discovered by Miss A. C. Maury, who, when examining the photographed spectra of Beta Aurigæ on forty-seven photographs, found that the star line doubled periodically like those in Zeta Ursæ Majoris, but at shorter intervals; in fact, that one of the stars goes round the other in two days. It is a startling discovery to find binary systems of this kind so very different from any previously known, and I think that there can be no doubt that this fact would have been hidden for ages to come but for photography, because until the discovery was made there was no apparent reason for everyday

* Abstract from the presidential address of H. C. Russell, F.R.S., Government Astronomer, Sydney.

examination of the spectrum of a star; indeed, until then, when the lines were once carefully measured they were put aside by the observer as finished and definite records of the star's spectrum. These first results indicate that the components of Beta Aurigæ are separated by an angular interval of only 0·004", a quantity so small that twenty years ago no one ever dreamed of being able to measure it.

At the meeting of the Royal Prussian Academy of Science on November 28, 1889, Prof. Vogel stated that he had photographed the spectrum of Algol six times—three in the winter of 1888-9 and three times in November, 1889—and that he found before the minimum the lines in the spectrum of Algol are displaced toward the red, showing that the star is receding, and after the minimum they are displaced toward the violet, showing approaching motion, and these facts can only be accounted for by the theory that Algol is associated with a dark star, and that the two revolve in the plane of the line of sight round the common center of gravity once in 68·8 hours. At minimum the dark star intercepts some of the light by being on this side of Algol, and the photographed spectrum further justified the conclusion that the diameter of the larger body was 1,074,000 miles; of the smaller one, 840,000 miles; the distance between them, 3,269,000 miles; the speed of Algol in its orbit, 27 miles per second; and of the dark one, 56 miles per second; and that the system was approaching the earth at the rate of 2 miles per second.

In March, 1891, it was announced that Prof. Rowland had accurately photographed the whole of the solar spectrum from D down to the extreme ultra violet, by means of concave gratings. It is the most perfect map of the solar spectrum that has ever been made. He has further proved that thirty-six terrestrial elements are certainly present in the solar spectrum, the presence of eight others is doubtful, and fifteen others (including nitrogen, as it shows itself under the electric spark) have not been found in it; and it follows, he thinks, that if the whole earth were heated up to the temperature of the sun, its spectrum would resemble very closely the solar spectrum.

On August 7, 1891, M. Deslandres exhibited the results he had obtained since May in photographing the bright lines of the solar prominences. The negatives show good reversals of the lines H and K, and the first two lines of the ultra violet hydrogen lines. Prof. Hale, of Chicago, also in the middle of April obtained the first reversals of the lines H and K by his method.

The year 1891 will ever be memorable in the annals of astronomy as that in which the great work of a photographic survey of the heavens, which was arranged in 1887 at the Paris conference, was actually begun.

The 24 in. star camera, the splendid gift of Miss Bruce, was nearly finished in January, 1893, and it had been decided to use it first at the Boyden Observatory, near Arequipa, under Prof. Pickering.

We now come to one of the most surprising results that has marked the application of photography to the wants of the astronomer. Several attempts had been made with more or less success to get a method by which the sun's surface and surroundings could be regularly studied, but Prof. George Hale, guided by what had been done by others, studied and succeeded in working out a new method, which seems to meet all, or nearly all, the requirements. He had completed this work ready to take solar photographs by January 22, 1892. He calls the instrument a spectro-heliograph, and by it the solar prominences, faculæ, and chromosphere can be clearly photographed by monochromatic light of the wave length K. It is not necessary here to describe the instrument; it will suffice if I mention the essential points of difference between the spectro-heliograph and an ordinary solar spectroscope. Let us suppose, then, that we have a solar spectroscope. The professor removes the fixed slit, and puts in its place one large enough to take in the whole of the sun and surroundings; this slit can, by suitable machinery, be made to move across the image of the sun. The grating is next so adjusted as to give only the K line of the spectrum. The ordinary eyepiece for viewing the spectrum is next removed, and in its place is fixed another movable slit, which is moved by the same machine as the other one, and at a definite relative rate; all being adjusted, the light of the K line of the spectrum will pass from the grating through the second slit, the use of which is to prevent any side light near the K line from falling on the sensitive surface; to complete the arrangement it is only necessary to put a sensitive plate very close to the second slit. Everything being ready, the telescope is uncovered and the slits set in motion. As the first moves across the image of the sun the second moves across the sensitive plate, and any K light passes through it and leaves its record on the plate in a position relative to that on the sun. Thus, practically, a series of very fine lines, sections, as it were, across the prominences are recorded side by side until the whole disk is included, and the photosphere and prominences clearly photographed. The operation requires first-rate apparatus and every precaution to insure success. I will only mention one contrivance. When the slits are adjusted and everything ready to take the photograph, a round disk of metal is put in front of number one slit; it is nearly as large as the image of the sun, and practically makes an eclipse of the brighter parts, leaving only the edge of the sun, the photosphere, and prominences and corona to pass to the spectroscope. The next point is to secure on the same sensitive plate a photograph of the faculæ and spots. The grating is now set, so that the combined slits only allow the faculæ light to pass. All is then prepared, so that the slits will move across the sun's disk and across the plate. The disk is removed, and the faculæ spots recorded in their true relative positions to the prominences. The apparatus is quite successful, and the professor thinks that, with a modification, he can also photograph the corona; but up to latest reports this has not been successful.

Encouraged by the success of his spectro-heliograph, Prof. Hale has designed for the Yerkes Observatory, Chicago, an improved spectro-heliograph, which will, when finished, carry seventy-two sensitive plates, and automatically record on each of them at any interval that may be desired complete pictures of the spots, faculæ, photosphere, and prominences in true relative position on each plate. All that will be necessary will be to set the telescope, wind up the machinery, and set it to work, the only limits being, first, that it takes two minutes to get a complete picture of the sun; and, second, the number of plates put in the wheel that carries them.

With the old system it took an hour's work to record the prominences alone; the new apparatus will do the same work far better in one minute. So far it has not been found impossible to photograph the corona with this apparatus, but experiments are in progress and confidently expected to succeed by which a modified spectro-heliograph will photograph the corona, using only the ultra violet light.

One remarkable result of Prof. Hale's spectro-heliograph work is the abundance of faculæ all over the sun from pole to pole, and seen thus they are of curved forms, generally like the figure 3, though spread over the whole surface they are strongest within 40° of the equator north and south, and the greater part of them are invisible to the eye, and in Prof. Hale's opinion they "are not to be confused with Janssen's reseau photospherique." Janssen, in 1869, in a paper read before the British Association meeting at Exeter, pointed out that it was possible to isolate any particular line in the spectrum by using two slits, one being near the eye.

On March 22, 1892, a photograph of Swift's comet was taken at the Sydney Observatory, which shows eight narrow rays extending from the head. As these were all quite invisible with the large refractor, it is probable that they were composed of blue or violet light, because if of white light, they would have been visible through some of the larger telescopes turned to the comet, if not through the Sydney refractor.

Prof. Schaerberle, at Lick Observatory, has recently photographed the corona by the method of absorption introduced by Dr. Huggins, and has obtained satisfactory pictures. He conducted the Lick expedition to observe the solar eclipse of April 16, 1893, and in his report he says that the observations and photographs of the eclipse taken confirm his opinion of the structure of the corona, and his photographs of it by Dr. Huggins' method. One of the eclipse pictures shows the dark sun 4 in. in diameter, and the corona round it covers a plate 18 in. by 22 in.

In March and April, 1893, selected parts of the Milky Way were photographed at Sydney with the large star camera and specially sensitive plates, with the results that parts that look nebulous in the photographs of 1890 are simply masses of stars, that a group that Herschel with his great telescope estimated to contain 200 stars, on the photograph contains 14,550, and that a well defined portion in Sagittarius, which in the 1890 plates contained eighty stars, is now found to contain 1166, or fourteen times as many.

Prof. Kapteyn, from his study of photographs taken at the Cape of Good Hope, was able to announce in March, 1893, that stars near the Milky Way and in it are photographically brighter than stars of the same visual magnitude which are at a distance from the Milky Way, and the difference is in proportion to the distance.

The photo-spectrographic method of measuring star motions has already been referred to, but the results have recently, in the hand of Dr. Kempf, given a new and quite independent determination of the rate and direction of the sun's motion in space. Dr. Vogel thought that fifty-one stars were not enough to give the result desired, but as the present apparatus is not powerful enough to determine the motion of any more stars, the computation was made, with the result that "the apex of the sun's way" is situated in R. A. 206° and north declination 46°, in the constellation Bootes, and that its motion in that direction is at the rate of eleven and a half miles per second. Many previous attempts have been made to locate the "apex of the sun's way," and they placed it in about R. A. 267° and north declination 31°. This older method affords no means of determining the rate of the sun's motion, unless an assumption was made as to the distances of certain stars, and this made the velocity sixteen miles per second, which does not differ very much from eleven and a half—the value determined from photographs.

As an index of the great accuracy attained at Potsdam in determining motion in the line of sight, it may be mentioned that six photographs of the spectrum Arcturus were taken, from which its motion in the line of sight was determined, and Prof. Keeler, using the great Lick telescope on three nights, determined the same quantity by eye measurements, and the two values agree within the tenth of a mile per second.

Prof. Keeler, using the great Lick telescope, 36 inch aperture, has determined the motion of several nebulæ in the line of sight, and finds values ranging from two to twenty-seven miles per second, and in one case forty miles per second.

In this brief outline of what photography has done, and is doing, much has been omitted for want of space, and in many places the bare facts are given in order of time simply to recall important steps in the progress to your memories. Even in its infancy photography was received kindly by astronomers, and although much was expected from it, nobody dreamt what it would be to-day. Sir George Airy, as we have seen, was very much impressed with what he saw, and he felt that a new power in astronomy was coming to the front; but it is evident that he had no adequate conception what it was going to do for exact records or for descriptive astronomy, or we should have had his great powers devoted to its development. But who could dream in those days that it would be possible now to say, as Prof. Pritchard has said, that in measuring distances of over 2,000 seconds of arc for his photo-parallax experiments he had found the probable error of the distance between two stars so measured to be only one-tenth of a second of arc, and that the camera and spectroscope combined, in Prof. Vogel's hands, had separated a double star with a distance of only six thousandths of a second of arc—a quantity so small that our great telescope will have to be enlarged thirtyfold before we can see it. And Prof. Vogel's determination of star motions in the line of sight has, in the opinion of competent persons, shown that attempts to determine the motions of stars in the line of sight without the aid of photography was little better than a waste of time. And Prof. Keeler, recently in charge of the great Lick telescope, and therefore having full knowledge of the powers of the greatest telescope in the world, writes it has been shown "that visual observation of the spectrum cannot in general compete with photographic methods applied to the same as even much smaller telescopes." Indeed, no one can study the results obtained by photography where it has been fully applied without being impressed by the fact that the results are not only far in excess of the amount possible by eye observation, but also of far higher value, and that after a time photography will displace the observer from all astronomical instruments and do much better work than he could ever hope to do with his eyes.

We have to-day passed in hurried review the application of photography to the wants of the astronomer in delineating the moon's surface in the study of her libration; to recording the sun's disk, his spots, faculæ, rice grains photosphere, red prominences, the corona in actual and in artificial eclipse; to the sun's motion in space; to the sun's rotation periods; to recording that wonderful spectrum with its thousands of lines; to the record of double stars; star charting; star magnitudes; to their classification by quality of light; to recording their almost inconceivable numbers; to star drifting; to star motions in the line of sight; to double stars so close and so remarkable that they can only be recorded by this means; to the record of all the visible stars in the sky for the purpose of detecting changes of magnitude; to the record of the spectrum of every star down to the tenth magnitude; to finding invisible stars and invisible lines in their spectra; in recording the forms and details of nebulæ; to their spectra, to show that the eye does not see all details they present nor their extraordinary extension; its application to recording the form and appearances of comets; to the record of the invisible rays in their tail; to their spectra; to the surface-marking of planets; to their spectra; to show their satellites, and to record the places of the satellite of Neptune, which it is difficult to see with any telescope, but is photographed easily; to proving that the light round Venus in transit is much brighter than the sunlight itself; to recording the lines in the ultra violet of the spectra of heavenly bodies, lines the existence of which otherwise must have remained for ever unknown to us, because they are invisible.

We have taken only a passing glance at many of the applications of photography, and each of them would repay a careful study. Indeed, the results obtained by means of photography come upon us so fast that one hardly realizes their importance. Think for a moment what it means to catch a fleeting ray of light that may be has for hundreds of years been flying through space with the inconceivable velocity of 180,000 miles per second, to catch and fix it on a photographic plate, and extort from it, not only where it came from, but the physical and chemical condition of the star it came from—whether it be old or young, coming to us or going away, whether the parent star has a bright or dark companion, their dimensions, distance apart, speed in their orbits, and their mass. To extort all this from a wandering ray of light is more wonderful than anything in romance; or, to turn in another direction, the photographic survey of the heavens now in progress, and many plates of which have been taken, will contain a record of at least 3,500 stars for every one we can see with the eye.

But grand, as the work has been so far, there is yet much to do, and more fields to conquer. It must replace the transit instrument with another more accurate and capable of recording all stars to the tenth or twelfth magnitude. It must find an instrument large enough to record the closest double stars, and such clusters as Omega Centauri. It must write at short intervals the exact forms of nebulæ as well as their spectra, showing motion in space, and so record their changes in form as well as their disappearance and appearance that any change will be detected; must make still more accurate records of the magnitudes and spectra of the stars; must sound the star depths in all directions, so that photographs of star clusters will show the stars still more accurately, and must find an automatic camera suited to its needs that will keep records of sun, moon, and stars; must picture the moon as perfectly as we can see it, and make it possible to compare minute details month after month, and so detect any changes. No doubt there are difficulties in the way, and even this moderate view of the wants of the future presents many, but they are not insuperable. The army of science is in one respect like the army of war—it is stirred to conquering effort by the difficulties that stand in the way. Given a citadel to be won, and there is always a forlorn hope to win it. Given a glimpse of one of nature's secrets—the photosphere, the prominences, and the corona hidden by the sunlight, except for a moment in each century—and at once you see the army: Huggins, and Airy, and Young, and Janssen, and Lockyer, and a host of others, all battling with the overpowering light of day in order to win the secret that it hides, winning bit by bit of the difficult way until success is attained.

With such a record of unexpected successes in the past, and so much more that is possible now, it would be folly to attempt to forecast what another ten years will bring forth. Everything points to an enormous increase in the details of the known, and to at least an equally great advance into the unknown. Photographs taken three years ago filled the dark places of the southern Milky Way with stars, and brought at least strong evidence that they have grouping exactly resembling the Milky Way near them—a sort of family likeness which cannot be mistaken. This year some Milky Way spaces taken with the camera of 1890 have been probed by the large star camera, and it may be mentioned, as a measure of the difference of the two instruments, that a well-defined but small space which in the 1890 photograph contains eighty stars is found in the 1893 photograph to have fourteen times as many stars, or 1,166. Now it is possible to-day to get a camera made ten times as powerful as those in use, and there is a talk, and one may say a probability, that in the very near future one will be made a hundred times more powerful. Moreover, the experience of the past has been that the limit in power of the telescope of one age is not the limit of the next. There has been a gradual expansion in the arts, which the astronomer has taken advantage of, and there is every reason to suppose this will continue in the future to an extent of which we can form no estimate. One is tempted to ask—Will the star depths unfold in the same ratio? And the reply comes in the words of the German poet—"Other worlds more bil-

lowy, other heights and other depths are coming, are nearing, are at hand; for end there is none to the universe of God!"

[Continued from SUPPLEMENT, No. 982, page 15702.]

GEOLOGIES AND DELUGES.*

By Prof. SOLLAS, F.R.S.

ON the mound of Kojundjik stood two great palaces, one of them that of King Assurbanipal. It was evidently not merely a royal residence, for one of its chambers at least was devoted to public purposes; this was the king's library, to which the citizens, who were taught in their early years to read and write, had free access. Whether any one of the books were written on papyrus is uncertain; all that have survived the conflagration, in which the palace was destroyed, are on tablets of kiln-made brick. Of such tablets many thousands have been recovered, not only from Nineveh but from other towns, and many of them are now preserved in the British Museum. Thus within the last fifty years modern Europe has obtained a glimpse, and more than a glimpse, into the literature of a civilization that perished just as the Roman was coming into existence; for, as Sir Walter Raleigh puts it, "In Alexander's time learning and greatness had not traveled so far west as Rome, Alexander esteeming of Italy but as a barbarous country, and of Rome as but a village. But it was Babylon that stood in his eyes, and the fame of the East pierced his ears."

The recovered literature covers a vast field of human interest, in science, as in astronomy and mathematics, particularly in astronomy, for the Chaldeans were famous star watchers, and had already named the stars and constellations, associating them with the deeds and mighty works of their heroes and demigods, so that the starlit sky became a pictured dome, and the zodiac a frieze to the Assyrian, reminding him of history or fable, like the sculptures and paintings which adorned the king's palaces; in religion and poetry, and in commerce, many of the tablets recording business contracts, and revealing a system of mortgage and banking, money being frequently lent at from 13 to 20 per cent., which was moderate; for the advantages of cent. per cent. were already known and appreciated by these simple Semitic folk.

It was among the tablets from King Assurbanipal's library at Nineveh that George Smith, now over twenty years ago, made a famous discovery. He found a fragment of a tablet, bearing words, which he deciphered as follows: "On the Mount Nizir the ship stood still. Then I took a dove, and let her fly. The dove flew hither and thither, but finding no resting place, returned to the ship." Every Englishman who knows his Bible would have guessed, as George Smith immediately did, that he had before him a piece out of a Chaldean account of the deluge. He searched for more fragments, and found them. He went out to Assyria, visited the king's palace, and found still more tablets and pieces of tablets, some of them just those he required to fill up missing gaps in the story. Since its first translation by its discoverer it has been again translated and retranslated by some of the acutest scholars in Europe, so that we now possess a fairly complete knowledge of it; a few missing words or even lines, and occasional obscurities occur, but these are of no great importance. In a town which has the privilege to number the distinguished Assyriologist, Prof. Sayce, among its residents, there will be no necessity to present the story more than briefly. It runs as follows: Sitnapistim, the Chaldean Noah, is warned by Ea, the god of wisdom and the sea, that the gods of Surippak, a city on the Euphrates, even then extremely old, had decided in council to destroy mankind by a flood. Sitnapistim is told to build a ship in which to save himself, his family, household, and belongings. Anticipating the curiosity of his neighbors, since he had never before built a boat, he asks what answer he is to make when questioned as to his unusual proceedings. Ea, who as the god of wisdom is naturally a master of evasion, provides him with a subterfuge, and Sitnapistim sets about building his boat. He forms it of timber and reeds, and makes it watertight by filling up the crevices with pitch, which he poured over it both within and without. It is of great interest, as showing the local coloring of the legend and the survival of an ancient custom, to observe that this practice of paying the native boats of the Euphrates with pitch has persisted in Mesopotamia down to the present day, natural pitch being used, which occurs at various localities in the valley, but particularly near the town of Hit. Sitnapistim's method of procedure, both in building and paying his boat, may still be witnessed at Hit as a matter of almost every day occurrence.

Sitnapistim having provisioned the vessel, and brought into it all his goods and chattels, received an intimation of the immediate approach of the catastrophe; he went on board with his family and friends, closed the roof, and prudently intrusted the helm to the sailor—Buzar-sadi-rabi. Heavy rain fell during an anxious night, and as soon as daybreak appeared—

> "There arose from the foundation of heaven, a dark cloud,
> The storm god Raman thundered in its midst and
> Nebo and Merodach went in front.
> As leaders they passed over mountain and plain.
> Ninib went therein, and the storm behind him followed.
> The Anunnaki raised high their torches,
> With their radiant brightness the land glittered,
> The turmoil of Raman reached to heaven,
> All that was light was turned to darkness.
> * * * * * *
> In the earth men perished. . . .
> Brother beheld not his brother, men knew not one another. In the heaven
> The gods were terrified by the deluge, and
> Hastened to ascend to the heaven of Anu.
> The gods were like a dog—sat down cowering on the ring wall of heaven.
> Ishtar cried like one filled with anger.
> Cried the mistress of the gods—the sweet-voiced—
> 'The former generation is turned to clay. . . .
> What I have borne, where is it?
> Like fish spawn it fills the sea.'"

For six days the flood lasted and ceased on the seventh, and then Sitnapistim is made to say—

> "I looked on the sea and called aloud,
> But the whole of mankind was turned to clay.
> I opened the air hole, and the light fell on my face:
> I bowed low, sat down, and wept,
> Over my face flowed my tears."

* British Association address to workingmen.

Sitnapistim then beheld the land, Mount Nizir, on which the ship grounded. It remained swinging there for seven days; on the seventh day Sitnapistim sent out a dove, which returned, then a swallow, which flew to and fro, but also returned, and finally a raven: "The raven went, saw the going down of the waters, came croaking nearer, but did not come back." Sitnapistim then left the ship with his people, built an altar on the summit of the mountain, and offered sacrifice. The poem then runs—

> "The gods smelt the savor, the gods smelt the sweet savor,
> The gods gathered like flies over the sacrificer.
> The mistress of the gods, Ishtar, lifted up the (bow?) which Anu had made according to her wish."

A discussion then takes place among the gods, who all through are very human, and in its course Ea suggests to Bel, who seems to have been the prime mover in all the mischief, that he should for the future destroy mankind in a less undiscriminating manner—by wild beasts, pestilence, and famine. The scene ends happily with the apotheosis of Sitnapistim and his wife.

The surprising resemblance of the story to the biblical narrative, extending into identity of words, as in the case of the "gods smelt the sweet savor," points to direct derivation or borrowing, and there can be very little doubt in deciding on which side the borrowing lay. The biblical narrative is indeed a Jahvistic or Monotheistic edition of the Chaldean. To this conclusion the most distinguished Assyrian scholars have been led. I need only mention here Prof. Sayce, whose opinion is expressed on page 119 of his work on "The Higher Criticism and the Monuments," published by the Society for Promoting Christian Knowledge, during the current year.

The Chaldean story certainly reduces the flood to much smaller dimensions, and so far brings it nearer the range of probability; the rain lasted only seven days, and the waters have subsided sufficiently at the end of a fortnight for Sitnapistim to land. They do not cover all the high mountains, and the stranding of the ship on Mount Nizir when the flood was at its climax gives us a maximum height, which it cannot have exceeded; for if this mountain had been deeply submerged, it could not have arrested the passage of the ship. The height of the Nizir mountains is about 1,000 feet above the sea level, which still leaves room for a very respectable flood.

The skepticism which prevailed in the middle of this century with regard to legends seems to have given place to an almost equally great credulity. The older argument seemed to be that the presence of some obviously unveracious statements in a legend condemned the rest, want of faith in some was want of faith in all; while the more modern view would appear to be that since so many discredited legends have been found to enshrine some important truth, all are to be assumed trustworthy till they are proved otherwise.

It may be in this spirit that Suess has elaborately discussed the Chaldean legend as though it presented us with a trustworthy account of the Mesopotamian deluge.

Reasoning from the facts as it records them, Suess lays great stress on the course taken by the ship from Surippak, supposed to have been situated near the mouth of the Euphrates, to the land of Nizir, a distance of about 240 miles up stream. Had the flood been produced solely by heavy rainfall and a consequent overflowing of the swollen rivers, the ship, instead of being carried inland, would have been drifted out to sea, i. e., southward into the Persian Gulf. Suess therefore suggests that a great wave was produced in the Persian Gulf, partly by a cyclone and partly by an earthquake. This wave of twofold origin then rolled in upon the low-lying land of Mesopotamia, and drove its floods of water up the valley till they washed the foot of the Nizir Hills.

Of all catastrophes, none are more terrible, none more disastrous than those thus produced. When the shock of an earthquake occurs beneath the sea, and affects the adjacent land, a trembling of the ground is first felt, then the sea retires and leaves the beach bare, only to return in a long mighty wave which breaks with violence on the shore. Thus on October 28, 1746, Callao in Peru, after being shaken by an earthquake, was overwhelmed by a sea wave and utterly destroyed; of its 5,000 inhabitants only 200 survived the flood. Still more destructive was the famous earthquake of Lisbon, November 1, 1755, when the inhabitants, without a warning, were destroyed in the falling city, and in six minutes 60,000 persons perished. The sea in this case, as in others, retired first, and then rose fifty feet or more above its usual level, swamping the boats in the harbor; at Cadiz the wave is said to have reached a height of sixty feet, and it was felt over the greater part of the North Atlantic Ocean, arriving even on our own shores, as at Kinsale in Ireland, where it rushed into the harbor and poured into the market place.

That a great sea wave so produced might have thus arisen in the Persian Gulf is quite within the bounds of possibility, particularly as a zone of the earth's crust, very liable to earthquakes, stretches across the mouth of the gulf near the Ormus Mountains.

But if we are to follow the legend, we must follow it faithfully, and as a result of the most recent investigations it turns out that all the passages which were supposed to refer to an earthquake have been mistranslated. The earthquake is thus put out of court, and we are left with what help we can get from the hurricane, a kind of disturbance which often vies with the earthquake in the destructive nature of the sea waves to which it gives rise.

The Andaman Islands of the East Indies are a center which give birth to some of the most terrific hurricanes in the world. Traveling more or less westward and northward, these whirlwinds sweep over the waters of the Bay of Bengal and raise the sea into waves mountain high, which every now and again rush over the low-lying lands of the Ganges delta, overwhelming the unfortunate inhabitants by myriads. Thus on the night of October 14, 1737, one of these waves, estimated at forty feet in height, suddenly overtook the dwellers by the Ganges and destroyed them to the number of 100,000, or, as some say, 300,000 souls. These storms do not, as a rule, travel toward the Persian Gulf, and the North Arabian Sea is singularly free from them; but Suess, tracing the course of the storm of October 24, 1842, suggests that for once, in the case of the deluge, an East Indian storm may have lost its way and blundered, as it were, into the Persian Gulf. The track of this storm of 1842 was as follows: At 5 o'clock on October 24 it reached Pondicherry; it then slightly altered its direction and veered more to the southwest, and on the 25th at midday it crossed the western Ghats, and then divided into two parts; the south center need not concern us. The northern center traveled northeastward toward the Persian Gulf, and was felt from the Gulf of Aden to Cap Guardafui, wrecking in this tract a number of vessels.

The greatest estimated height of storm waves is from forty to forty-five feet, and, as Suess points out, it must have needed a much greater wave than this to drown out all Mesopotamia up to the Nizir Hills. How much greater, is a question we are fortunately able to answer positively, thanks to the accurate measurements made by the Engineer Czernik during a survey for a projected railway. The Tigris rises very slowly from its mouth inland, but at Bagdad it is already 154 feet above the sea level, and at Mansurijah, the lowest point where its tributary Diala Tschai emerges from the Hamrin Mountains, the height is given as 285 feet; but the land of Nizir lies even still more to the north than this, and the Lower Zab, which cuts through it, cannot have a less elevation than 600 or 700 feet. No storm wave of which we have any record, no recorded earthquake wave, nor any combination of the two, approaches even remotely the height that would be required to carry the sea even to Bagdad; while as for the Nizir Mountains, the Valiant Pherson, who "nearly spoilt the flood," might have drank up all the sea water which came there without any assistance from Glenlivat. If we admit that the Tigris valley was ever submerged up to this point and restored to its original condition in the course of fourteen days, we are confronted with a catastrophe not only stupendous in degree, but of a nature beyond our present powers of explanation.

But are we compelled to admit anything of the sort, and would it not be well before doing so to inquire a little more closely into the credentials and character of the Chaldean story? We have seen that the tablets on which it occurs were found in King Assurbanipal's library, and it is fairly certain that they were copied from others much older preserved in the ancient city of Erech, the city of books. It is indeed probable that the tablets in Erech may date from the time of King Khammarubi, or from about 2350 B. C. The tablets present themselves therefore with good recommendations, and we proceed to the character of the story itself. It does not occur alone, but as one chapter out of twelve in a long poem of about 3,000 lines, concerning the adventures of a mythical hero named Izdubar or Gizdubar, perhaps the same as Nimrod, that "mighty hunter before the Lord" of biblical story, and plainly the prototype of the Greek Heracles.

The first tablet, containing the first chapter, is incomplete. So far as can be made out, it sets forth the misfortunes of the city of Erech, probably under the oppression of its Elamite enemies, who were so terrible in battle that poor Ishtar, its protecting goddess, "could not lift up her head against the foe."

The second and third introduce Gizdubar, already famous as a hunter, as the hero who was looked for to deliver the city. His rivals induce Ururu, the mother of the gods, to fashion a strange being, Eabani, half man and half bull, to fight with Gizdubar. This monster comes to Erech, bringing with him a powerful lion, desert bred, to fight Gizdubar; but the hero succeeds in slaying the lion, and so wins the friendship and esteem of Eabani. In the fourth and fifth tablets the friends encounter and overcome the terrible tyrant Humbaba, whose voice was as "the roaring of the storm, his mouth wickedness and his breath poison." The sixth tablet, which is well preserved, tells how the hero was beloved of Ishtar. "Be my husband," she says, "and I will be thy wife. I will make thee to ride in a chariot of gold and precious stones, with golden wheels and diamond horns. When thou enterest our house under the pleasant fragrance of the cedar, men shall kiss thy feet. Kings, princes and lords shall bow down before thee and bring tribute."

Gizdubar, however, is not to be seduced; he repels the advances of the goddess, who then presents herself as a naturally angry woman before her father Anu, and persuades him to frame a divine bull which is to destroy Gizdubar. He and Eabani together slay this bull, however, and the goddess, now terribly incensed, pronounces a terrible curse upon Gizdubar. The seventh tablet is unfortunately missing. The eighth, ninth and tenth narrate how Gizdubar, suffering under the divine anger, loses his friend Eabani, and is smitten with a grievous illness. He journeys to the river's mouth to consult his divine ancestor Sitnapistim. On his way he crosses a desert where "scorpion men" guard the dark path to the "waters of the dead," which separate him from his quest.

On the shore of this sea he finds a park of the gods, with wonderful trees bearing precious stones for fruit. After waiting here a long time a ferryman takes him over to the fields of the blessed, where he meets Sitnapistim. He tells his sorrowful tale, and the heart of Sitnapistim is filled with pity; but, alas! neither gods nor men can give him help. In the eleventh tablet Gizdubar inquires of Sitnapistim how he became immortal, and receives in answer the story of the deluge. After its recital Sitnapistim heals Gizdubar of his disease and gives him the plant of life, its name being "Altho'-a-grey-beard-the-man-becomes-young-again." Unfortunately an evil demon robs him of this on the way home. In the twelfth and last tablet Gizdubar returns to Erech, and utters a lament over his lost friend Eabani, whose ghost subsequently appears and recounts the doings of the dead in Hades.

Thus the deluge story is a myth within a myth, containing statements plainly unveracious; and how we are to distinguish in this mass of fiction the true from the false, passes the wit of man to conceive. If we say of the deluge part of it that it is a gross exaggeration, the judgment will sound mild, but this is all that is requisite to reduce the catastrophe to commonplace proportions.

Whether Gizdubar ever existed in the flesh or not has been doubted; it is certainly remarkable that each of the chapters of the poem corresponds to one of the signs of the zodiac, and they are arranged in the same order as the signs of the zodiac. A fanciful correspond-

ence is thus drawn between the succession of events in the life of Gizdubar and the yearly course of the sun through the heavens, and it has consequently been maintained that Gizdubar is no other than the sun himself personified. The stages in the life of man find, however, so ready an analogy in the course of the sun, that this conclusion is by no means forced upon us, and we may turn to another identification of more significance in our inquiry. It is that of the Greek story of Heracles with the legend of Gizdubar. Heracles himself is no other than a Greek Gizdubar, the Chaldean Eabani corresponds to the centaur Cheiron, the tyrant Humbaba to the tyrant Geryon, the divine bull to the bull of Crete, the park of the gods to the garden of the Hesperides, the lion slain by Gizdubar to the lion of Nemea which Hercules slew; and finally, just as Gizdubar is ferried across the waters of the dead, so Hercules is taken by Helios in the golden boat of the sun across the ocean.

As the Greeks have borrowed so much of the legend it would be surprising if they had not taken the rest, including the story of the deluge, and accordingly we find the Greeks provided with a legend of the flood, or with more than one, as they appear to have had more than one Heracles; but that which most closely accords with the Chaldean is the flood of Deukalion.

On the other hand, the Egyptians, who had sun stories of their own, did not borrow the legend of Gizdubar, and are silent as to a deluge—a fact of extreme importance when we consider that the Egyptian civilization was contemporaneous with the Chaldean, if not indeed older. The Nile is gentler in its overflowing than the Tigris, so that Egypt did not suffer under the scourge of unexpected floods.

If, finally, we turn to China, also possessed of very ancient historic records and liable to the destructive deluges of the Yellow River, which have earned for it the designation "the Curse of China," we discover a deluge story of great importance, to which Suess has already called attention. In the third Schu of the Canon of Yao, a monarch who reigned, it is supposed, somewhere about 2357 B. C., and therefore contemporaneous with Khammurabi, we read: The Ti said, "Prince of the Four Mountains, destructive in their overflowings, are the waters of the flood. In their wide extension they inclose the mountains and cover the great heights, threatening the heaven with their floods, so that the lower people is unruly and murmur. Where is a capable man whom I can employ this evil to overcome?" Khwan was engaged, but for nine years he labored in vain; a fresh engineer, named Yu, was therefore called in; within eight years he completed great works: he thinned the woods, regulated the streams, dammed them and opened their mouths, provided the people with food and acted as a great benefactor to the state.

It is refreshing thus to pass from the ornate deceptions of legend to the sober truth of history; and if the facts on which the Gizdubar legend of the deluge is founded could be expressed in the same simple language, we should probably find it narrating similar events, or events as little calculated to surprise us as those of the straightforward Chinese Schu.

History, then, fails to furnish evidence of any phenomenon which can be called catastrophic in the geologic sense of the word, and geology has no need to return to the catastrophism of its youth; in becoming evolutional it does not cease to remain essentially uniformitarian.

And the careful foster-mother? She too, as it appears to me, has widened her studies, and must, I should think, recognize with pride the stalwart growth of her early friend. May they be drawn nearer together and feel the warm glow which is produced by the sympathy of a common love for truth.

[The Technic.]

THE U. S. GEOLOGICAL SURVEY.

The U. S. Geological Survey is doing work which is not suggested by its title. It is making a topographic map of the United States. If its title were framed to more exactly express its functions and duty, it would be called the U. S. Topographical and Geological Survey. It is now a little more than thirteen years old, having been created by an act of Congress passed at the very end of the 45th session, March 3, 1879. Prior to its creation the government had engaged in studying the little known areas of the far West, the Rocky Mountains, and the other great mountain systems farther west, with their intervening valleys and deserts. Here vast tracts existed which had barely been seen by white men and of which no surveys or maps existed. For intelligent legislation as to the disposition of this public domain it was necessary to secure information about its resources both on the ground and in the ground; resources in water and timber, and resources in coal and minerals.

Prior to 1879 three surveys were in existence, all engaged in this class of work, and known as the Hayden, Powell and Wheeler surveys. Under Captain George M. Wheeler the War Department was making maps on a scale of eight miles to an inch and without contours. The Hayden survey, so named from its director, Dr. F. V. Hayden, of Philadelphia, under the Interior Department, was also engaged in making maps and studying the general geology of the region. Its most important outcome in map making was an atlas of Colorado on a scale of four miles to an inch, and with contour intervals of 200 feet. The Powell survey, so named from its director, Major J. W. Powell, was similarly engaged under the Interior Department in making maps and in studying the geology of Arizona, Utah, and adjacent regions.

The act of Congress which created the Geological Survey was passed for the purpose of reorganizing this work and placing it on a more systematic and uniform basis. The act which created it discontinued the three prior organizations. The work of those three surveys was confined substantially to a period of ten years following the war, that is, beginning in 1867 or 1868, they continued to work until 1879. Their work was wholly confined to the great West. When the Geological Survey was created as their successor, the work was expanded. The field of its operations was declared by law to be the national domain, and the question was soon raised as to what constituted the national domain. On this there was long and earnest debate in Congress, and in 1882 it was practically determined by the action of the House of Representatives that the national domain, as applied to the Geological Survey at least, meant the entire domain over which the stars and stripes float, East and West, North and South. Thus authority was given for doing work not merely in the great West, but in the East as well. The Geological Survey thereupon entered upon the general work of preparing a topographic map of the whole United States.

In order to exhibit the structure and resources of the country, topographic maps are necessary. Without such maps, geologic work must needs be slow, expensive and unsatisfactory. Geologic surveys have existed and now exist in many of the States, but there is probably not a single director of any State survey who has not found his work greatly impeded and possible results much reduced by the absence of topographic maps.

Our situation in this respect is peculiar. In all European states the geological surveys found topographic maps ready to their hands. Such maps had been made for military purposes, and were promptly made use of for other purposes when the need became apparent. With us, however, all geologic surveys, State and national, have met this obstacle of lack of topographic maps. About ten years have elapsed since Congress formally authorized the making of such maps, and their making abs rbs nearly one-half the energies and annual appropriations of the Geological Survey. To obtain a clear understanding of the character of this great topographic or mother map which the Geological Survey is making, readers of the Technic should, if interested in this matter, examine samples of the sheets in the library of the University. These atlas sheets are projected without regard to political or physical features, and cover an area of either one "square degree," one-quarter of a "square degree," or one-sixteenth of a "square degree." Those which cover one degree of latitude by one degree of longitude are on a scale of 1:250,000, or approximately four miles to one inch. This small scale is no longer used. A considerable tract of country in the far West has been mapped on this scale, and with contour intervals of 200 or 250 feet.

The next larger scale is 1:125,000, or approximately two miles to one inch. Atlas sheets on this scale cover half a degree of latitude by half a degree of longitude. The Appalachian mountain system and large areas in Texas, Arkansas, Missouri, Kansas, Colorado and California have been mapped on this scale. The contour interval is in general 50 feet on this scale.

The largest scale used is 1:62,500, or approximately one mile to one inch. These atlas sheets, of the same size as the two preceding, cover fifteen minutes of latitude by fifteen minutes of longitude, or one sixteenth of a "square degree." When these maps embrace a flat country, the contour interval is small, in some cases so small as five feet, in others ten feet, but in general the contour interval is twenty feet. On this mile scale Massachusetts, Rhode Island, Connecticut and New Jersey have been completely surveyed, while considerable areas on the same scale have been surveyed in New York, Wisconsin, Iowa, Illinois and Louisiana.

The maps are drawn, engraved and printed in three colors, black being used for the cultural features, blue for all water bodies, and brown for all hill forms. The form of the surface of the country is shown by contours. The work is designed to be accurate to scale, that is, to be free from visible errors. If we assume the one-hundredth part of an inch as the limit of visible error on the published map, then each point on the largest scale used must be determined within 53 feet of its true position in nature. In the process of locating points within this limit of error, necessarily some of them must be determined far closer. The initial or base lines upon which the work rests must be so accurately determined that their errors, when multiplied, shall not in the end introduce an error visible on the map.

The rate of progress of this work is determined by the amount of money which Congress annually appropriates for carrying it on. During the past few years the amount annually expended has been about $250,000, and the areas surveyed from 40,000 to 50,000 square miles per year. The total area mapped to date is nearly 600,000 square miles, or about one-fifth of the United States, and the total cost somewhat more than $2,000,000. More or less work has been done in nearly every State in the Union. There are but four or five States or Territories out of the forty-nine that have not had some portion of their areas topographically mapped. Michigan is one of the States in which the area surveyed is quite small, that small area being confined to the iron region of the northern peninsula.

I have already mentioned that four States, to wit, Massachusetts, Rhode Island, Connecticut and New Jersey, are already completely mapped. The reason for this is that the citizens of those States, through their Legislatures, co-operated with the Geological Survey to hasten the completion of their maps. Each of those States, through its Legislature, appropriated one-half the estimated cost of mapping, and authorized such appropriations to be expended by the United States Geological Survey. Under this system of co-operation it was possible for these States to promptly secure the advantages of a completed map.

MARCUS BAKER.

Washington, D. C., April 21, 1894.

SOAKING WITH ELECTRICITY.

The so-called storage batteries do not store electricity, properly speaking. They store chemical energy which may be turned into electrical energy at will. The only real storage batteries are the condensers, of which the Leyden jar, well known in lecture room experiments, is the most familiar type. Several curious facts connected with the charge and discharge of such condensers have received careful investigation recently, among which is the so-called "soaking in" of part of the charge and its appearance later as a "residual charge." In a paper read before the American Institute of Electrical Engineers, September 19, 1894, Messrs. Bedell and Kinsley described their study of some of the conditions on which this effect depends. Every condenser, as is known, consists of two metallic sheets separated by a non-conductor, or of a series or pile of such. When one has been charged it acts as if part of the charge remained upon the metallic plates while part soaked into the non-conductor. When the condenser is discharged only the former portion takes part in the discharge; the latter gradually comes to the surface, and in time the condenser may be discharged again, though no charge has been given it meanwhile. A series of residual charges, diminishing in intensity, may thus be formed. The condition of a condenser depends, therefore, on its history—on its condition for weeks, or even months, past. In solid dielectrics the absorption is less, as the temperature is higher. In pure oils there is none at all.

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